STATE WATER RESOURCES CONTROL BOARD

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

Designated March 21, 1974, April 18, 1974, and June 19, 1975

1. *Pygmy Forest Ecological Staircase*
2. *Del Mar Landing Ecological Reserve*
3. *Gerstle Cove*
4. *Bodega Marine Life Refuge*
5. *Kelp Beds at Saunders Reef*
6. *Kelp Beds at Trinidad Head*
7. *Kings Range National Conservation Area*
8. *Redwoods National Park*
9. *James V. Fitzgerald Marine Reserve*
10. *Farallon Island*
11. *Duxbury Reef Reserve and Extension*
12. *Point Reyes Headland Reserve and Extension*
13. *Double Point*
14. *Bird Rock*
15. *Ano Nuevo Point and Island*
16. *Point Lobos Ecological Reserve*
17. *San Miguel, Santa Rosa, and Santa Cruz Islands*
18. *Julia Pfeiffer Burns Underwater Park*
19. *Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge*
20. *Ocean Area Surrounding the Mouth of Salmon Creek*
21. *San Nicolas Island and Begg Rock*
22. *Santa Barbara Island, Santa Barbara County and Anacapa Island*
23. *San Clemente Island*
24. *Mugu Lagoon to Latigo Point*
25. *Santa Catalina Island — Subarea One, Isthmus Cove to Catalina Head*
26. *Santa Catalina Island — Subarea Two, North End of Little Harbor to Ben Weston Point*
27. *Santa Catalina Island — Subarea Three, Farnsworth Bank Ecological Reserve*
28. *Santa Catalina Island — Subarea Four, Binnacle Rock to Jewfish Point*
29. *San Diego—La Jolla Ecological Reserve*
30. *Heisler Park Ecological Reserve*
31. *San Diego Marine Life Refuge*
32. *Newport Beach Marine Life Refuge*
33. *Irvine Coast Marine Life Refuge*
34. *Carmel Bay*

CALIFORNIA MARINE WATERS

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

RECONNAISSANCE SURVEY REPORT

PACIFIC GROVE MARINE GARDEN FISH REFUGE
AND HOPKINS MARINE LIFE REFUGE
MONTEREY COUNTY

STATE WATER RESOURCES CONTROL BOARD

SURVEILLANCE AND MONITORING SECTION

APRIL, 1979
WATER QUALITY MONITORING REPORT NO. 79-11

ACKNOWLEDGEMENT

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Karen Sjogren, Andrea McDonald, Kathleen Casson, and Mark Silberstein. The latter report was prepared in fulfillment of an agreement with the California Department of Fish and Game, which has coordinated the preparation of a series of Area of Special Biological Significance Survey Reports for the Board under an Interagency Agreement.

ABSTRACT

Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge Area of Special Biological Significance (ASBS) is located at the southwest corner of Monterey Bay. It is adjacent to the town of Pacific Grove in Monterey County.

The coastline of the ASBS is 3.3 miles long with Pt. Cabrillo and Pt. Pinos marking the approximate eastern and western boundaries, respectively. The area of the ASBS is about 680 acres.

Most of the bluffs adjacent to the ASBS have been landscaped, and few species of native vegetation remain. However, the native Monterey cypress is found in the coastal parks.

Winds, bottom topography, tidal cycles, and the proximity of the open coast influence currents within the ASBS. Current patterns are also influenced by prevailing offshore currents including the California Current and the Davidson Current. As the California Current travels south along the coast, surface waters are driven offshore. This causes upwelling of deeper waters along the coast.

The average sea surface temperature along the shoreline of the ASBS is 13.14°C. Sea surface temperatures are considerably colder than ocean temperatures at this latitude; this is due to the proximity of the Monterey Submarine Canyon which allows deep, colder oceanic water access to the bay. Persistent summer fog also depresses surface temperatures by reducing incident radiation.

Subtidal surveys revealed habitats with high species diversity of both vertebrates and invertebrates. Giant kelp dominates the subtidal zone. The kelp bed is most extensive at Pt. Pinos where there is more rocky substrate.

The surf and shallow water zone areas are characterized by exceedingly dense and jungle-like plant growth. Surf grass dominates large areas of the bottom, often interspersed with kelp.

The intertidal substrate of the ASBS consists of granite boulders and outcrops, interspersed with small, sandy coves. Species diversity and abundance is generally limited. Sea lettuce, split whip, rockweed, and corallines are examples of the algal species found within the ASBS; while the aggregating anemone and the solitary anemone, barnacles, crabs, red abalone, brown and black turban snails, and various sponges are examples of the diverse fauna found at Pacific Grove Marine Life Refuge.

Sea otters, an endangered species, have great influence on the subtidal community within the ASBS. The California population of otters, once thought extinct, has expanded in numbers and range around Pt. Pinos and into the ASBS. Abalone is a preferred food item of the otter; however, otters also feed upon urchins, mussels, rock crabs and squid.

The ASBS consists of two adjacent, separately designated, marine reserves. The eastern portion of the ASBS includes Hopkins Marine Life Refuge. The western portion encompasses Pacific Grove Marine Gardens Fish Refuge. The term marine gardens refers to the extensive kelp beds in this area.

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FINDINGS AND RECOMMENDATIONS

Findings

1. The location of the ASBS at the outer, southernmost extreme of Monterey Bay results in oceanographic and biological features that resemble those of the open ocean.

2. The ASBS is relatively close to the Monterey Submarine Canyon and may be affected by canyon as well as coastal upwelling.

3. The oceanographic seasons in the ASBS, particularly in the western portion, generally correspond with those offshore.

4. Currents in the ASBS are weak, highly variable, and largely influenced by the wind. There is some evidence of a clockwise gyre, or predominantly onshore water movement, during the Upwelling Period.

5. Because the ASBS is in close proximity to upwelling activity, is shallow, and adjacent to no major drainages, the following conditions exist: (1) surface temperatures are low; (2) thermoclines are unstable and poorly developed; (3) salinity is high and does not fluctuate radically; (4) dissolved oxygen is relatively low; and (5) nutrient levels vary spatially and temporally.

6. The geology of the ASBS is relatively simple, with both rock and sediments consisting of Santa Lucia granodiorite. Both the intertidal and subtidal substrate consist of rock, with areas of coarse grain sand interspersed.

7. The ASBS has a Mediterranean climate. Upwelling activity encourages a high incidence of fog, which in turn moderates air temperature.

8. The narrowness of the intertidal zone in the eastern portion of the ASBS appears to limit species diversity and abundance; both of the latter features increase to the west as the intertidal zone widens.

9. Sport fishing and limited commercial fishing occur in the ASBS, including squid fishing, a locally important fishery.

10. The intertidal zone of the ASBS has been used extensively, primarily by Hopkins Marine Station, for scientific research. More recently, the University of California at Santa Cruz and the Department of Fish and Game have investigated the subtidal zone of the ASBS.

11. The Pacific Grove sewage treatment plant discharges about 1.4 MGD primary treated effluent to the shallow subtidal zone .4 miles west of the ASBS. The discharge is to be phased out by mid 1980. Pt. Pinos appears to partially prevent the discharged waste water from reaching the ASBS.

12. Hopkins Marine Station discharges a maximum of 93,000 gpd from its seawater (aquaria) system to the ASBS, at four discharge points. The seawater discharge water quality characteristics do not appear to differ significantly from those of ambient seawater.

13. Numerous storm drains discharge to the ASBS. They cause localized changes in land vegetation, turbidity, and salinity, but do not appear to constitute a major source of water pollution to the ASBS.

14. Both the CALCOFI and Hopkins Marine Station sampling programs have provided valuable oceanographic information on this area. Daily measurements by Hopkins are particularly valuable as they allow comparison of short-term and longer term variability of water quality.

15. The seawall adjacent to the ASBS is important in mitigating cliff erosion and channeling and controlling access to the intertidal zone.

Recommendations

1. City and State boundaries and regulations for Pacific Grove Marine Gardens Fish Refuge should be made consistent to improve enforcement capabilities.

2. Following elimination of the Pt. Pinos wastewater discharge, both the ASBS and refuge boundaries should be extended westward to include Pt. Pinos; a western projection of Lighthouse Avenue would be a convenient boundary line. The rocky intertidal zone in the proposed area is more extensive than in the ASBS and is historically important as the location of the "Great Tidepool", so named because a great deal of earlier collecting and research activity occurred there.

3. Long-term ecological studies should be encouraged. These studies allow assessment of long-term natural variability in the ASBS, which is necessary before the effects of water pollution and human activity can be distinguished.

INTRODUCTION

The California State Water Resources Control Board, under its Resolution No. 74-28, designated certain Areas of Special Biological Significance (ASBS) in the adoption of water quality control plans for the control of wastes discharged to ocean waters. The ASBS are intended to afford special protection to marine life through prohibition of waste discharges within these areas. The concept of "special biological significance" recognizes that certain biological communities, because of their value or fragility, deserve very special protection that consists of preservation and maintenance of natural water quality conditions to practicable extents (from State Water Resources Control Board's and California Regional Water Quality Control Boards' Administrative Procedures, September 24, 1970, Section XI. Miscellaneous--Revision 7, September 1, 1972).

Specifically, the following restrictions apply to ASBS in the implementation of this policy.

1. Discharge of elevated temperature wastes in a manner that would alter natural water quality conditions is prohibited.

2. Discharge of discrete point source sewage or industrial process wastes in a manner that would alter natural water quality conditions is prohibited.

3. Discharge of wastes from nonpoint sources, including but not limited to storm water runoff, silt and urban runoff, will be controlled to the extent practicable. In control programs for wastes from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.

4. The Ocean Plan, and hence the designation of Areas of Special Biological Significance, is not applicable to vessel wastes, the control of dredging, or the disposal of dredging spoil.

In order for the State Water Resources Control Board to evaluate the status of protection of Pacific Grove Marine Garden Fish Refuge ASBS, a reconnaissance survey integrating existing information and additional field study was performed by Karen Sjorgren, Andrea McDonald, Kathleen Casson, and Mark Silberstein. The survey report was one of a series prepared for the State Board under the direction of the California Department of Fish and Game and provided the information compiled in this document.

ORGANIZATION OF SURVEY

The subtidal area of the ASBS was surveyed by diving along six evenly spaced line transects, four short (60 m) and two long (340 m). The transects were located in an attempt to observe changes in flora and fauna accompanying the east-west exposure gradient. Half the transects were surveyed before the first major winter storm which had a significant effect on the biota observed. The remainder were surveyed after the storm. For each transect, substrate types, species composition and relative abundance, and number of kelp plants were recorded. Core samples (4"-6" depth) were taken at approximately 20 ft., 40 ft., and 60 ft. depths. The number of stipes per kelp plant was estimated. The literature was reviewed and incorporated in the discussion portion of the description and is annotated in the bibliography. The species list is based on the survey dives only.

Four intertidal sites in Pacific Grove Marine Gardens Fish Refuge were surveyed, again spaced so as to observe changes in flora and fauna accompanying the exposure gradient. An extensive literature review of intertidal studies in the area was conducted, and these are referenced in the species lists (Appendix 3 and 4) as well as in the annotated bibliography.

The chapter entitled Land and Water Use Description incorporates information from knowledgeable individuals, unpublished data, public agency documents, and personal observation.

The description of sources of water pollution is based on examination of treatment plant records, discussions with and tours by plant personnel, agency documents, relevant oceanographic studies, unpublished student reports, and interviews with other knowledgeable individuals.

All aspects of the description were augmented by photographic slides, as weather permitted.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge Area of Special Biological Significance is located at the southwest corner of Monterey Bay. It is adjacent to the town of Pacific Grove, population 17,000, in Monterey County.

The ASBS is oriented in a northwest-southeast direction. For purposes of description, the ASBS is considered to lie along an east-west axis. Land areas are only south of the ASBS, and offshore bay waters are north of the ASBS.

The length of the coastline adjacent to the ASBS is 3.3 miles (5.3 km). The coastline is characterized by numerous granite outcroppings and interspersed sandy coves. Lovers Point is the most extensive outcropping and lies midway between the eastern and western boundaries of the ASBS. Pt. Cabrillo is a large promontory of land near the eastern boundary of the ASBS and is the location of Hopkins Marine Station. Otter Point (.8 miles or 1.3 km from the western boundary) and Lucas Point (.4 miles or 0.6 km from the western boundary) also lie adjacent to the ASBS (see Figure 1).

The coastline becomes more exposed to coastal waters as it proceeds from east to west along the ASBS. Pt. Pinos, only 0.3 miles (0.5 km) west of the ASBS, marks the southern end of Monterey Bay. This long, low-relief granite point continues subtidally as a shallow rocky reef, which is an extreme navigational hazard. Both the point and the reef offer considerable protection to the western half of the ASBS, which would otherwise be completely exposed to the open ocean.

The seaward boundary of the ASBS is an average of 0.43 miles (0.69 km) offshore. The Pacific Grove Marine Gardens Fish Refuge boundary line follows the 60 ft. depth contour; Hopkins Marine Life Refuge boundary line is 1000 ft., (305 m) offshore and approximates the 60 ft. depth con-

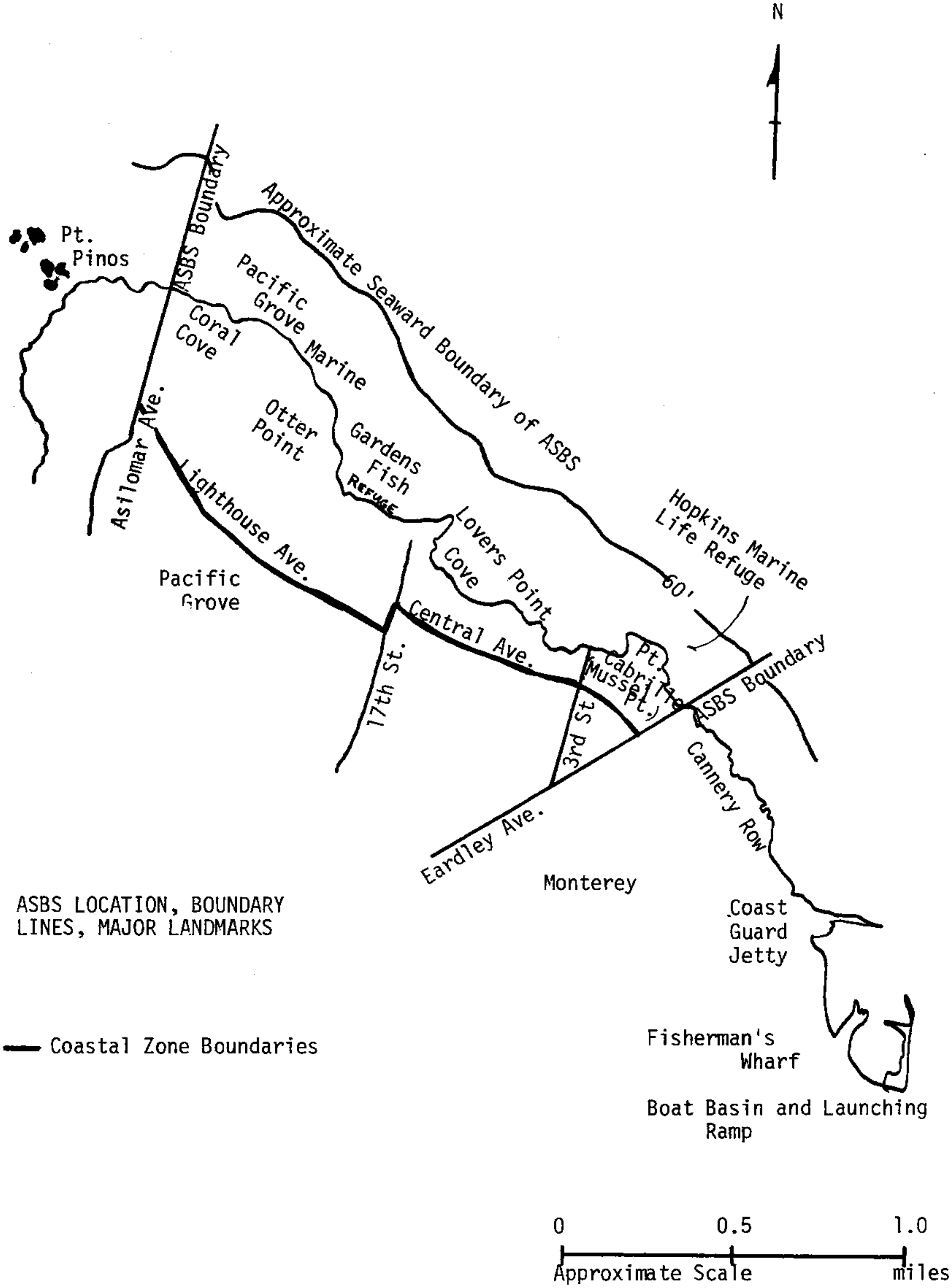

FIG. 1: ASBS LOCATION, BOUNDARY LINES, MAJOR LANDMARKS

tour, as well. The surface area of the ASBS is approximately 680 acres (275 hectares).

The western seaward boundary of the ASBS is at 36°38'36"N latitude, 121°55'42"W longitude and is a seaward extension of Asilomar Avenue. The eastern seaward boundary is at 36°37'24"N latitude, 121°53'54"W longitude and is a seaward extension of Eardley Avenue (Figure 1). The official boundary description as stated in the State Water Resources Control Board publication Areas of Special Biological Significance (1976), is as follows:

> Ocean areas within the following boundaries as they existed April 1, 1963: Beginning at the point of intersection of the southeasterly corporate limit line of the City of Pacific Grove produced, and the line of mean high tide of the Bay of Monterey; thence northwesterly along said line of mean high tide to the intersection with the westerly corporate limit line of said City (Asilomar Avenue produced); then north 19° 22' east along said westerly corporate limit line produced, to the point in the Bay of Monterey where the depth of water in said bay is sixty (60) feet measured from the level of mean low tide; thence southeasterly along the line in said bay which line is at a constant depth of sixty (60) feet measured from the level of mean low tide, to the intersection with the southeasterly corporate limit line of said city produced; thence south 58° 58' west along said southeasterly corporate limit line produced, to the point of beginning.

Nearshore Waters

Currents: Currents within the ASBS are weak and variable. Because this is a nearshore area, winds, bottom topography and the tidal cycle exert considerable influence on the speed and direction of currents at any particular time. However, the ASBS is also located in close proximity to the open coast, and current patterns are also influenced by prevailing offshore currents.

The southward flowing California Current predominates in offshore surface waters between about February and October. This current is the eastern leg of the massive, clockwise-moving North Pacific Gyre; consequently, it brings waters of more northern origin to the central California coast. The influence of the California Current on circulation patterns in the bay depends largely on its speed, which varies seasonally. When it first appears in surface waters, in February, the California Current has an average speed of about .04 knots. Current speed increases rapidly to 0.21 knots in March, and reaches a maximum of 0.28 knots in July. Subsequently, the speed decreases to about 0.07 knots in September and October (Lammars, 1971).

The seasonal presence of the California Current corresponds with that of the Pacific high pressure cell, which is responsible for prevailing northwest winds. As the California Current travels south along the coast, surface waters are driven to the right, or offshore, by the combination of northwest winds and the Coriolis force. Upwelling of deeper waters occurs along the coast, causing this oceanographic season to be termed the Upwelling Period. According to Broenkow (in press), the closest area of coastal upwelling is 6 to 12 miles (10 to 19 km) south of Monterey Bay.

Northwest winds and the California Current both weaken in the early fall, allowing offshore, oceanic water to invade nearshore regions. Both the onset and duration of this oceanographic season, the Oceanic Period, are highly variable; it generally occurs between September and October.

The Davidson Period, from about November to February, is characterized by the surfacing of the Davidson Current, a massive, northward flowing countercurrent. Throughout most of the year, the Davidson Current flows beneath the California Current, at depths greater than 655 ft. (200 m). It gradually rises to shallower depths in the fall and reverses current direction intermittently even in surface waters during the winter. This current carries equatorial Pacific water of higher salinity and temperature than generally exists at this latitude and has an important moderating effect on winter ocean temperatures.

As with the California Current, the influence of the Davidson Current on Monterey Bay circulation patterns depends somewhat on its speed. Current speed increases from about 0.04 knots in November to a maximum of 0.14 knots in December and January, and current direction shifts from the south to the southeast.

The onset of the Davidson Period corresponds with the advance of atmospheric low pressure cells, and often begins abruptly with the year's first winter storm. The northward flowing current is deflected onshore by the Coriolis force, and downwelling results. Particularly during storms, downwelling is evidenced by large nearshore swells and causes vertical mixing to depths of up to 163 to 330 ft. (50 to 100 m).

Upwelled waters enter Monterey Bay near Pt. Pinos, following the contours of the submarine canyon, and exit near Santa Cruz to the north. As the canyon is oriented in a southwest-northeast direction, the entrance of upwelled water imparts a general counter-clockwise current pattern in the Bay. However, a portion of the entering water sometimes splits off at Pt. Pinos and forms a clockwise eddy near the ASBS.

Oceanic waters generally reach the ASBS during a portion of the Oceanic Period, as the ASBS is located at the outer edge of the bay. The blue, warmer oceanic water is easily distinguished from the bay's typical cold, greener water. Currents are probably weaker and more variable than during the Upwelling Period. There is evidence that a clockwise gyre, or at least eastward currents, persist in the south bay through September (Stoddard in Lammars, 1971; ESI, 1970). However, surface currents are directed more towards the north. By October, south bay circulation patterns appear to be absorbed into the larger, counterclockwise gyre of the north and central bay. Reise (1973) found that nearshore currents off Cannery Row tended to be directed offshore, such that drift bottles were recovered often near Santa Cruz. When water movement was onshore, recoveries were made at a more westerly position than during the Upwelling Period. This could be attributed to a lessening of northwest winds and/or disappearance of a clockwise gyre in the south bay.

The Davidson Current is more sluggish than the California Current, and thus its effect on bay circulation is more easily counteracted by prevailing winds. Blaskovich (1973) estimated that the Davidson Current determined surface circulation patterns in the bay only when wind speeds were less than one meter per second (about 2.2 miles per hour).

Winds: Wind has a major effect on surface water currents in the ASBS. Since the direction and magnitude of both local and larger scale winds is continually in a state of flux, surface currents tend to be erratic and rarely attain much velocity in any particular direction.

To a certain extent, surface current speed varies directly with that of the wind. The wind factor in surface currents has been estimated at between 2.2 to 4 per cent (Blaskovich; Broenkow), thus inducing currents of between 0.04 to 0.4 knots, depending on wind speed. As indicated previously, the velocity of offshore currents ranges between about 0.04 to 0.28 knots. Thus, the effect of winds on local currents is at least comparable to that of offshore currents; maximum current speeds could be expected when the two forces act together.

The afternoon sea breeze appears to cause onshore water movement, particularly during the Upwelling Period. Winds are generally weaker during the remainder of the day, and surface current direction may be dictated by the prevailing offshore current (Reise, 1973).

Tides: Monterey Bay has a diurnal tidal cycle, with two high and two low tides of unequal height. The tidal cycle has little influence on bay circulation because the mouth of the bay is wide and the nearshore is narrow. Thus, tidal flows are not accelerated by constriction as occurs at the Golden Gate; Skogsberg (1936) noted that tidal streams were usually less than one knot in velocity.

Water entering the bay on an incoming tide is generally denser than nearshore water, so it enters along the bottom. This causes a seaward displacement of both surface waters. As the tide ebbs, surface waters are again moved onshore. Skogsberg (1936) noted that surface water moved offshore at 0.3 knots on a flood tide, and back onshore with the ebb tide at a speed of 0.36 knots. The Association of Monterey Bay Area Governments reported onshore surface currents of 0.39 to 0.46 knots in the south bay on an outgoing tide in September. The onshore water movement generated by the tides is probably augmented by the effect of onshore winds, and therefore the current velocity is greater than on a flood tide.

In other studies of surface currents, Blaskovich (1973) and Stevenson (1964) were unable to relate changes in current speed and direction specifically to the tidal cycle. Most likely wind is the dominant force affecting surface currents; tides may be instrumental in causing wind-induced changes to occur over a longer or shorter period of time.

Water Column Characteristics: The average sea surface temperature along the shoreline of the ASBS is 13.14°C (56°F), as determined by measurements taken at Hopkins Marine Station over the 25-year period from 1938-1963 (Table 1). Sea surface temperatures are considerably colder than most other ocean temperatures at this latitude; this is due to the proximity of the Monterey Submarine Canyon, which allows deep, colder oceanic water access to the bay. Persistent summer fog also depresses surface temperatures by reducing incident radiation.

Sea surface temperatures at shore exhibit little seasonal variation. Temperatures generally range from a minimum of 11.04°C (52°F) in January to a maximum of 15.82°C (61°F) in September (Table 1). The average annual range in monthly temperatures is only 2.58°C (5°F), between 11.83-14.40°C (53-58°F). The moderate seasonal fluctuations are due to the fact that upwelling depresses sea temperatures in the spring and summer, when insolation is greatest, whereas winter and fall surface temperatures are elevated by the presence of southerly offshore currents and possible freshwater runoff.

As in much of Monterey Bay, shore temperature fluctuations within a week or month commonly equal or exceed seasonal variations in the ASBS. Basically, short-term fluctuations are greatest during the summer and early fall, when maximum thermoclines exist. In nearshore waters, the

TABLE 1: SEA SURFACE TEMPERATURE DATA, DEGREES CENTIGRADE: PACIFIC GROVE MARINE GARDENS FISH REFUGE AND HOPKINS MARINE LIFE REFUGE ASBS

MONTH	SST-HMS 1938-1963 Average	SST-HMS 1938-1963 Ave./Extreme Minimum	SST-HMS 1938-1963 Ave./Extreme Maximum	SST-HMS 1938-1963 Ave./Extreme Monthly Range	SST-HMS Date of CALCOFI Data	SST-CALCOFI Station 1 (1971-1972)	SST-AMBAG 1124(Pt. Pinos) (1971-1972)	CALCOFI 1 Sea Temp. 20 Meters Depth	Pt. Pinos Sea Temp. 20 Meters Depth	CALCOFI 1 Thermocline C°/20 Meters	Pt. Pinos Thermocline C°/20 Meters
JANUARY	12.02	11.04 / 9.3 (1949)	12.84 / 14.3 (1941)	1.8 / 3.0 (1962)	10.9 (1/20/72)	11.05	11.46	11.01	11.04	-.04	-.42
FEBRUARY	12.11	11.14 / 9.7 (1953)	12.91 / 15.0 (1958)	1.77 (1961) / 2.4 (1950)	11.3 (2/17/72)	11.42	11.58	11.26	10.70	-.16	-.88
MARCH	12.15	11.22 / 9.6 (1953)	13.17 / 15.0 (1941)	1.95 / 2.9 (1953)	12.2 (3/23/72)	12.14	12.07	10.75	10.06	-1.39	-2.01
APRIL	12.51	11.23 / 10.0 (1956)	13.84 / 16.9 (1958)	2.61 / 4.4 (1958)	12.6 (4/20/72)	11.99	11.77	9.12	10.41	-2.87	-1.36
MAY	13.01	11.52 / 10.7 (1960)	14.57 / 17.0 (1941)	3.05 / 4.9 (1958)	13.7 (5/15/72)	13.33	11.57	10.04	9.86	-3.29	-1.71
JUNE	13.60	11.91 / 10.2 (1939)	15.17 / 18.2 (1958)	3.26 / 5.1 (1947)	13.5 (6/19/72)	13.54	12.15	11.73	10.47	-1.81	-1.68
JULY	14.10	12.41 / 10.9 (1955)	15.65 / 16.9 (1941)	3.24 / 4.7 (1938)	14.8 (7/13/72)	12.20	16.22	11.12	13.38	-1.08	-2.84
AUGUST	14.20	12.70 / 11.2 (1956)	15.72 / 17.3 (1941)	3.02 (1957) / 4.2 (1950)	15.5 (8/30/72)	15.92	15.59	11.94	12.10	-3.98	-3.39
SEPTEMBER	14.40	12.90 / 11.4 (1954)	15.82 / 17.7 (1958)	2.92 / 4.8 (1958)	14.3 (9/21/72)	14.62	13.68	13.47	12.87	-1.15	-.81
OCTOBER	14.00	12.39 / 10.9 (1954)	15.39 / 17.5 (1957)	3.00 / 4.6 (1956)	12.6 (10/20/71)	13.03	13.14	12.86	11.16	-.17	-1.98
NOVEMBER	13.03	11.87 / 10.4 (1947)	14.13 / 15.7 (1941)	2.26 / 4.2 (1938)	11.7 (11/18/71)	12.36	11.56	11.23	11.02	-1.13	-.54
DECEMBER	12.59	11.57 / 10.1 (1949)	13.59 / 15.3 (1941)	2.02 / 3.4 (1949)	10.0 (12/18/71)	10.03	9.84	10.06	9.68	+.03	-.16
EXTREMES/ AVERAGES	13.14	11.83 / Jan. 9.3 (1949)	14.40 / June 18.2 (1958)	2.58 / 5.1 (1947)	12.8	12.64	12.55	11.22	11.06	-1.42	1.48

thermocline is easily disrupted by local winds, surf or tidal changes, causing vertical mixing and abrupt decreases in surface water temperatures.

Comparative data indicate that sea surface temperatures in more offshore portions of the ASBS can be approximated with data from CALFOFI Station 1 and AMBAG Station 1124 (Miller, DF&G, unpublished data). During the Oceanic and Davidson Period, sea surface temperatures are generally lower near shore, where vertical mixing is greater. However, sea surface temperatures are generally lower offshore during the Upwelling Period and particularly low off Pt. Pinos, where upwelling is most intense. The maximum range of 2.13°C between the three stations occurred in May and is due to an upwelling-induced drop in sea surface temperature at Pt. Pinos (Table 1).

At both nearshore and offshore stations, winter temperatures in the ASBS are slightly lower than for Monterey Bay as a whole (mean temperature of 12.5°C (54.5°F). Skogsberg attributes these colder nearshore temperatures to the formation of eddies which prevent the intrusion of warmer oceanic or Davidson Current waters.

Thermocline: The ASBS is a shallow water area inside Monterey Bay, yet in close proximity to the open coast. Thermocline characteristics are therefore influenced by (1) coastal upwelling, (2) Monterey Submarine Canyon upwelling, (3) diurnal wind and tidal patterns, and (4) submarine topography. Basically, thermocline formation in the ASBS is weak and unstable due to the predominance of upwelling in the seasonal and localized oceanographic regime.

Coastal upwelling is particularly strong offshore from Pt. Pinos and discourages thermocline formation by inducing vertical mixing in at least the western half of the ASBS. The dominant influence of coastal upwelling is indicated by a weaker thermocline at Pt. Pinos (AMBAG Station 1124) as compared with areas to the east (CALCOFI Station 1). This occurred during April, May and November of the AMBAG 1971-72 survey (Table 1).

Canyon upwelling generally acts to steepen the thermocline in shallow areas of the bay, such as the ASBS. In the Monterey canyon, cold water begins to upwell towards the surface as early as February (Skogsberg, 1936). However, upwelled water does not affect the thermocline in the shallows until much later, when it starts to sink and is deflected horizontally and shoreward by canyon walls. As the southern canyon wall is steeper, horizontal deflection of upwelled water is also greater, allowing intrusion of cold water along the bottom into more nearshore areas. Canyon upwelling probably contributes more towards thermocline formation in the eastern portion of the ASBS and is responsible for the lower temperature at 20 meter depths and greater thermocline stability at CALCOFI station 1 in April and May of 1972 (Table 1). At Pt. Pinos, any influence of canyon upwelling on thermocline formation is apparently obscured by vertical mixing in this more exposed area, at least during the Upwelling Period.

Offshore winds weaken thermocline formation by inducing upwelling or downwelling. In the south bay, the sequence of strong offshore winds, upwelling, and thermocline reappearance can all occur within a week's time. Weekly oscillations in temperature gradients can therefore exceed monthly changes and be of the magnitude of annual changes in monthly averages (Lasley, 1977). The afternoon sea breeze probably weakens any thermocline which may have formed during morning hours, by causing a mixing of surface layers.

Although tides have a minimal influence on large-scale circulation patterns in Monterey Bay, they probably promote vertical mixing in the ASBS and thereby weaken existing thermoclines.

Bottom topography has a disruptive influence on thermocline where it causes wave formation or any other type of turbulence. Rocky reefs thus tend to interrupt thermocline existence, but in shallower water, the attached kelp probably has a stabilizing influence during the summer.

The only measurements of a thermocline within the ASBS were taken in Hopkins Marine Life Refuge by DF&G between 1968-70. The average thermocline during the entire study period was 7.3°C/50M, much higher than that at the offshore stations or the average maximum of 3.5°C/50M recorded by Skogsberg for Monterey Bay. The steeper thermocline could be due to greater surface insolation, plus the intrusion of upwelled canyon water to an even shallower bottom depth (46 ft. or 13.9 m average at the two DF&G stations). The average thermocline was 0.1°C higher in the kelp beds and only noticeably higher in August. A minimum gradient of 0.4°C/50M occurred in January in the kelp bed; a maximum gradient of 19°C/50M occurred in August, also at the kelp bed station.

The seasonal progression of the thermocline at the CDFG study site is basically the same as at the CALCOFI 1 station offshore. However, surface temperatures are higher earlier in the year possibly because upwelling is not as great here and insolation can therefore heat surface waters more effectively.

<u>Salinity</u>: The salinity characteristics of the ASBS resemble those of the open ocean. Because of the wide opening of Monterey Bay and the presence of the Monterey Submarine Canyon, ocean water has good access to nearshore areas and is the major factor which determines salinity and halocline features. Discharge from the Salinas River into Monterey Bay is of relatively low volume, highly seasonal, and occurs a good distance from the ASBS. During the winter months, when river flow is high, the Davidson Current tends to direct the discharge north rather than south.

The average surface salinity in nearshore waters of the ASBS is 33.5 parts per thousand (ppt), based on a 25 year average of daily measurements at Hopkins Marine Station (Table 2). This approaches the salinity of the open ocean, which is about 34 ppt at this latitude. The average minimum salinity is 33.19. The relative stability of surface salinity is an indication of the low volume of freshwater inflow.

The halocline, or salinity gradient, has not been measured within the ASBS. Undoubtedly, the steepest halocline exists during the rainy season, when low salinity water is superimposed upon bay water of average salinity. Close to shore, wave action probably prevents a halocline from

TABLE 2: SURFACE SALINITY DATA, PARTS PER THOUSAND: PACIFIC GROVE MARINE GARDENS FISH REFUGE AND HOPKINS MARINE LIFE REFUGE ASBS

MONTH	S-0 Meters HMS. 1938-1963 Average	S-0 Meters HMS. 1938-1963 Ave./Extreme Minimum	S-0 Meters HMS. 1938-1963 Ave./Extreme Maximum	S-0 Meters HMS. 1938-1963 Ave./Extreme Monthly Range	S-0 Meters CALCOFI 1 (1971-1972)	S-0 Meters AMBAG 1124 (Pt. Pinos) (1971-1972)	Salinity 20 Meters CALCOFI 1 (1971-1972)	Salinity 20 Meters Pt. Pinos (1971-1972)	CALCOFI 1 Halocline PPT/20 Meters	Pt. Pinos Halocline PPT/20 Meters
JANUARY	33.36	32.97 / 32.00(1942)	33.55 / 33.98(1961)	.58 / 1.42(1942)	33.55 (1/20/72)	33.54 (1/21/72)	33.56	33.58	+.01	+.04
FEBRUARY	33.28	32.87 / 30.25(1941)	33.55 / 33.95(1961)	.68 / 2.58(1941)	33.48 (2/17/72)	33.49 (2/18/72)	33.49	33.57	+.01	+.08
MARCH	33.22	32.49 / 28.16(1963)	33.53 / 34.02(1963)	1.04 / 5.86(1963)	33.47 (3/23/72)	33.58 (3/24/72)	33.62	33.67	+.15	+.09
APRIL	33.36	32.91 / 29.11(1958)	33.64 / 34.18(1939)	.73 / 4.33(1958)	33.59 (4/20/72)	33.56 (4/19/72)	33.88	33.65	+.29	+.09
MAY	33.57	33.20 / 30.82(1958)	33.80 / 34.22(1961)	.60 / 2.72(1958)	33.80 (5/15/72)	33.85 (5/24/72)	33.86	33.89	+.06	+.04
JUNE	33.68	33.45 / 32.98(1958)	33.87 / 34.34(1962)	.42 / .83(1941)	33.71 (6/19/72)	33.78 (6/19/72)	33.76	33.79	+.05	+.01
JULY	33.71	33.50 / 32.59(1960)	33.92 / 34.96(1963)	.42 / 1.43(1963)	33.75 (7/13/72)	33.46 (7/19/72)	33.78	33.51	+.03	+.05
AUGUST	33.69	33.52 / (1948) 33.39(1951)	33.85 / 34.29(1963)	.33 / .81(1963)	33.57 (8/30/72)	33.58 (8/30/72)	33.57	33.59	None	+.01
SEPTEMBER	33.64	33.49 / 33.30(1958)	33.79 / 34.26(1962)	.30 / .51(1949)	33.59 (9/21/72)	33.53 (9/29/72)	33.57	33.57	-.02	+.04
OCTOBER	33.55	33.35 / 32.88(1938)	33.69 / 33.97(1962)	.34 / .81(1957)	33.50 (10/20/71)	33.49 (10/22/71)	33.50	33.56	None	+.07
NOVEMBER	33.49	33.34 / (1947) 33.15(1961)	33.66 / 33.94(1961)	.32 / .79(1961)	33.38 (11/18/71)	33.53 (11/19/71)	33.53	33.54	+.15	+.01
DECEMBER	33.43	33.16 / 32.03(1955)	33.71 / 33.82(1960	.55 / 3.04(1963)	33.62 (12/16/71)	33.74 (12/17/71)	33.62	33.77	None	+.03
EXTREMES/ AVERAGES	33.50	33.19 / March 28.16(1963)	33.71 / July 34.96(1963)	.53 / March 5.86(1963)	33.58	33.59	33.65	33.64	+.06	+.05

forming. The halocline becomes well formed beyond the surf line, then disappears where offshore waters are beyond the influence of the freshwater inflow. Therefore, the offshore extent of the halocline depends upon the severity and duration of a particular storm, as well as tidal and surf conditions.

A halocline may be more pronounced in nearshore waters adjacent to large storm drain discharges. Kelp beds may also enhance halocline formation by reducing surge; however, large beds are generally absent during the season of heaviest rainfall.

Bigelow (1928) noted that pools of lower salinity water sometimes get trapped below the surface during the winter. In the spring, upwelling forces these pools to the surface and acts thereby to reduce rather than increase surface salinity.

The more offshore waters of the ASBS are generally beyond the influence of freshwater inflows and, therefore, the surface salinity and halocline do not vary much with the seasonal pattern of rainfall. Salinity characteristics are quite stable and uniform throughout the top 65 ft. (20 m) of the water column. The limited variation appears to be caused by localized and seasonal upwelling activity and predominance of different offshore currents.

A reverse halocline is not uncommon during the late summer and early fall. The Oceanic Period brings into the bay water which is more saline, but also warmer, so it tends to enter the bay along the surface. Evaporation also increases surface salinity during this period. Both factors can cause a slight negative salinity gradient to exist until winds cool the surface waters or cause vertical mixing. A reverse halocline is probably less common in upwelling areas, where subsurface salinity is higher and surface evaporation is reduced. A slight negative halocline existed in September in the vicinity of the ASBS (Engineering-Science Inc.).

<u>Dissolved Oxygen</u>: Dissolved oxygen (DO) concentration in the ASBS is limited primarily by physical and chemical features of the marine envi-

ronment. Salinity is typically high, reducing the solubility of atmospheric oxygen in surface waters. Thus, dissolved oxygen values can be quite low, as compared with other bays, and still be close to air-saturation levels. For example, during the 1971-72 AMBAG survey year, the average DO at the Hopkins and Pt. Pinos stations was only 5.9 mg/l throughout the top 65 ft. (20 m) of the water column (Table 3). However, the average percent saturation was close to 100%, based on seawater density at the time samples were taken. Surface DO is particularly low during the Oceanic Period, when warmer sea surface temperatures further depress the air-saturation point.

Upwelling causes colder, oxygen deficient water to continually be brought to the surface, thereby lowering surface DO values and obliterating any vertical gradient which may have developed. The variability of upwelling activity in the ASBS probably affects DO values, as well as other water column characteristics. On the average, DO values are slightly higher at CALCOFI Station 1 than at the AMBAG Pt. Pinos station, which is closer to coastal upwelling activity (Table 3). The surface water DO at Pt. Pinos is much lower during March, May and June, (e.g., months associated with persistent upwelling). However, the surface DO was higher at Pt. Pinos in August, September and October, possibly reflecting the presence of oceanic water of higher oxygen content.

The average DO differential from 0 to 65 ft. (0 to 20 m) at both stations was about -1.5 mg/l (range of +0.96 to -4.75 mg/l) during the 1971-72 AMBAG survey (Table 3). However, the gradient frequently varied between the Pt. Pinos and CALCOFI (Hopkins) stations. At CALCOFI Station 1, a maximum gradient occurred during April and May. Photosynthesis probably contributed to the high surface DO value, and the low value at 65 ft. (20 m) could be attributed to the intrusion of upwelled canyon waters. At Pt. Pinos, maximum stratification occurred in September and October. Intrusion of oceanic water is probably responsible for the higher surface values, whereas lack of vertical mixing caused dissolved oxygen in deeper waters to drop.

A 1968-69 DF&G kelp bed study contains the only data on DO concentration from within the ASBS. Measurements were taken at a kelp bed station and in a sandy bottom area about 1000 ft. (305 m) offshore. The average DO throughout the water column was 6 mg/l at both stations, with no significant differences noted between the two stations during any sampling period (Miller, unpublished data). The average differential between surface and bottom at the offshore station was +1.74 mg/l, slightly higher than the gradient at both the AMBAG and CALCOFI stations offshore in 1971-72. The vertical gradient was highest in April and May, at which time the DO at 65 ft. (20 m) dropped as low as 2.8 mg/l. As at CALCOFI Station 1, the maximum gradient appears to occur when upwelled canyon water intrudes along the bottom and is not immediately mixed with shallower, oxygen rich water.

Although upwelling initially depresses surface water DO values, it also brings nutrient-rich waters to the surface and thereby creates phytoplankton blooms. In shallow water areas, the increased photosynthetic activity may partially offset the initial decrease in surface water DO caused by upwelling. Thus, upwelling periods are often followed by a horizontal stratification of surface DO in the bay, with the shallows having the highest values. Because of the high productivity in the ASBS and the continual mixing of surface waters, there is probably little long range variation in DO values. However, wide fluctuations from long term averages are common and reflect the dynamic nature of the water column.

Turbidity: Turbidity levels within the ASBS vary spatially, seasonally, and often diurnally.

Spatial variations are caused by differences in bottom topography, substrate type, and sediment size. Turbidity generally decreases towards the west end of the ASBS, as the coarser sand here settles out more quickly if disturbed (K. Casson, pers. comm.). There is less turbidity above the rocky reef west of Otter Point than at the Lovers Point reef because the reef contains less interspersed sand. Turbidity increases shoreward, as wave action increases. During the 1968-69 kelp bed study (Miller, unpublished data) the average secchi disk reading was 20 ft. (6 m) in the nearshore kelp beds, and 22 ft. (6.8 m) 1000 ft. (305 m) offshore. Over a similar time period (1 year), the average secchi disk reading was 29.7 ft. (9 m) at CALCOFI Station 1, about 1/4 mile offshore from DF&G stations.

Seasonal variation in turbidity is caused by biological as well as physical features of the area.

Freshwater runoff causes turbidity in nearshore waters during and after storms, particularly at storm drain discharge points. Upwelling increases turbidity by inducing vertical mixing and plankton blooms, to the extent that visibility is often at a minimum during the spring. The DF&G kelp study (Miller, unpublished data) recorded minimum secchi disk readings of 5-1/2 to 6 ft. (1.67 to 1.88 m) in March. Maximum visibility often occurs during the Oceanic Period, as the influx of oceanic water is clearer than typical bay water. The DF&G study recorded a maximum secchi disk reading of 31 ft. (11.3 m) in November; a maximum secchi disk reading of 48 ft. (17.6 m) was also recorded in November during the AMBAG study (Table 3).

Local winds probably cause diurnal variations in turbidity close to shore. Winds are generally greater at Pt. Pinos than at Pt. Cabrillo and may cause an increase in turbidity (Table 3).

Nutrients: The sources of nutrients in shallow portions of Monterey Bay were first studied by Bigelow (1928). Bigelow found that the greatest concentrations of silicate, phosphates and nutrients were found at great depths ($\geq$ 1967 ft. or 600 m), and concluded that upwelling was an important means of making such nutrients available to phytoplankton in the photic zone. However, he also noted that the concentration of silicate and phosphate showed the greatest increase at 0 to 164 ft. (0-50 m) and that values increased shoreward. This indicated that the shoal bottom is itself an important local source of these nutrients, as it is the repository for diatoms and other organisms which die and sink to the bottom.

Nutrient concentrations were not available for waters within the ASBS. However, several years' data exists for CALCOFI station, and nutrient measurements were also taken offshore from Pt. Pinos during the AMBAG 1971-72 survey. Both stations are about 1/4 mile seaward of the ASBS, and values there probably reflect nutrient concentrations, gradients, and trends within the ASBS. Average values for all nutrients are high, as compared with other areas in Monterey Bay (Table 4).

From the one year's data presented, there does not appear to be a seasonal trend in the concentration of nutrients at either station. This would indicate that the source of such nutrients is not the seasonally upwelled water from the submarine canyon. Lasley (1977) postulated that changes in nutrient concentration in the south bay were related to coastal upwelling offshore from Pt. Pinos. As northwest winds and concomitant upwelling are not restricted to any particular time of year, nutrient concentrations can likewise increase dramatically at any time, and short-term fluctuations can approach seasonal extremes. For example, nutrient concentrations at Pt. Pinos in December, 1972, approached those occurring in the upwelling "season" (May, 1971).

Lasley found that coastal upwelling sets up a horizontal gradient in nutrient concentration from Pt. Pinos eastward to Monterey. The negative gradient is created by the assimilation of nutrients by an increasing phytoplankton population and a gradual sinking of remaining upwelled nutrients. These factors cause the increase in nutrient concentration to be of very short duration, with values dropping by as much as 80% only three or four days after the onset of upwelling.

Lasley estimated that the negative gradient eastward was 0.04 mg-at/l/km for phosphate and 0.6 mg-at/l/km for nitrate. Between the western and eastern boundaries of the ASBS, the concentration of phosphate should then decrease by 0.2 mg-at/l and that of nitrate by 3.0 mg-at/l. Lasley's estimates are fairly consistent with differences between the two stations in Table 4, when values are high (presumably, a period of upwelling). For phosphates, his estimate is within range for December, November, and May. For nitrate, it approximates the station differences in May, June, November and December.

TABLE 4: NUTRIENT AND NH_3 DATA: PACIFIC GROVE MARINE GARDENS FISH REFUGE AND HOPKINS MARINE LIFE REFUGE ASBS

MONTH	CALCOFI 1 Average Phosphate 0–20M	AMBAG 1124 (Pt. Pinos) Average Phosphate 0–20M	CALCOFI 1 Average Silica 0–20M	Pt. Pinos Average Silica 0–20M	CALCOFI 1 Average Nitrate 0–20M	Pt. Pinos Average Nitrate 0–20M	CALCOFI 1 Average Nitrite 0–20M	Pt. Pinos Average Nitrite 0–20M	CALCOFI 1 Average Ammonia 0–20M	Pt. Pinos Average Ammonia 0–20M	Monterey Average Ammonia 0–10M
JANUARY	1.10 (+ gradient) (1/20/72)	No Data	13 (- gradient)	No Data	12.5 (no gradient)	No Data	.54 (+ gradient)	No Data	3.12 (+ 0-5M) (- 5-10M)	No Data	.60 (- 0-5) (+ 5-10)
FEBRUARY	.57 (+ gradient) (2/17/72)	.73 (+ gradient) (2/18/72)	8 (+ gradient)	6 (+ gradient)	6.2 (+ gradient)	5.7 (+ gradient)	.54 (+ gradient)	.37 (+ 0-10M) (- 10-20M)	8.89 (- gradient)	.43 (+ gradient)	.77 (- 0-5) (+ 5-10)
MARCH	.68 (+ gradient) (3/23/72)	1.15 (+ gradient) (3/24/72)	4 (+ gradient)	13 (+ gradient)	7.8 (+ gradient, 1C)	7.6 (+ gradient)	.31 (- 0-5M) (+ 5-20M)	.23 (+ gradient)	4.2 (+ 0-5M) (- 5-10M)	.17 (+ gradient) (0-10M)	0
APRIL	.80 (+ gradient) (4/20/72)	.59 (+ gradient) (4/19/72)	No Data	3.5 (+ gradient) (10-20M)	5.6 (+ gradient, 1C)	3.9 (+ gradient, 1C)	.15 (- 0-5M) (+ 5-20M)	.10 (+ gradient)	19.57 (++ 0-5M) (-- 5-10M)	0	.2 (no gradient)
MAY	1.38 (+ gradient) (5/15/72)	1.67 (+ gradient) (5/24/72)	15.5 (+ gradient)	23 (no gradient)	15.3 (+ gradient)	19.0 (+ gradient, 0-10M)	.26 (+ gradient)	.28 (+ 0-5M) (- 5-20M)	1.52 (+ gradient, 1C)	.17 (+ gradient) (0-5M)	.8 (+ 5-10M)
JUNE	.85 (+ gradient) (6/19/72)	1.28 (+ gradient) (6/19/72)	9 (+ grad.0-10) (- grad.10-20)	15 (+ gradient)	10.4 (+ gradient)	13.5 (+ gradient)	.33 (+ gradient)	.26 (- gradient)	1.87 (- 0-10M)	.63 (- gradient)	.1 (+ 5-10M)
JULY	1.16 (+ gradient) (7/13/72)	.37 (+ gradient) (7/19/72)	14 (no gradient)	2 (+ gradient)	13.0 (+ gradient)	.6 (+ gradient)	.36 (+ gradient)	.04 (+ gradient)	6.88 (-- gradient)	0	.2 (+ 5-10M)
AUGUST	.64 (+ gradient, 1C) (8/30/72)	.44 (+ gradient) (8/30/72)	4 (+ gradient) (10-20M)	7 (- grad.0-10M) (+ grad.10-20M)	4.8 (+ gradient, 1C)	7.8 (+ gradient)	.17 (+ gradient) (-5-10M)	.11 (+ gradient)	3.79 (+ 0-10M)	.2 (no gradient)	.5 (+ 5-10M)
SEPTEMBER	.76 (- gradient) (10/5/72)	.80 (+ gradient) (9/29/72)	No Data	10 (+ gradient) (10-20M)	6.1 (+ gradient) (9/21/71)	3.4 (+ gradient, 1C)	No Data	.31 (no gradient)	3.41 (-- gradient)	0.0 (no gradient)	.1 (+ 5-10M)
OCTOBER	.58 (- gradient) (10/20/71)	1.04 (+ gradient) (10/22/71)	6 (+ gradient)	10 (- gradient)	2.6 (no gradient)	7.4 (+ gradient)	.19 (+ gradient) (- 0-5M)	.21 (+ gradient) (0-10M)	.86 (-- gradient)	.88 (-- gradient)	.3 (+ 0-5M) (- 5-10M)
NOVEMBER	1.16 (+ gradient) (11/18/71)	1.34 (+ gradient) (11/19/71)	11 (+ gradient)	14 (no gradient)	8.5 (+ gradient)	14.4 (- gradient) (0-5M)	.07 (+ gradient) (- 5-10M)	.38 (no gradient)	3.5 (-- gradient)	.81 (-- gradient)	1.77 (- gradient)
DECEMBER	1.12 (no gradient) (12/16/71)	1.64 (+ gradient) (12/17/71)	12 (- gradient)	20.5 (no gradient)	9.4 (- gradient) (0-10M)	16.8 (+ gradient)	.76 (+ gradient)	.25 (- gradient) (10-20M)	.97 (+ gradient)	.89 (- gradient)	.42 (+ gradient)
AVERAGE	.9	1.0	9.3	12.3	8.2	9.1	.31	.22	5.04	.38	.47

The horizontal gradient between the two stations is sometimes reversed for reasons unknown. Local sources of nutrients (i.e., marine mammals and birds) at the CALCOFI station could cause higher concentrations. In addition, oceanic water could cause a greater decrease in surface water nutrient concentration at Pt. Pinos than at Hopkins.

Using AMBAG and CALCOFI data, it is difficult to discern consistent vertical gradients in nutrient concentration between the surface and 65 ft. (20 m) depths. Generally speaking, concentrations increase with depth, indicating that phytoplankton assimilation is greatest in the upper five to ten meters, and that nutrients are sinking, rather than upwelling, between 0 and 65 ft. (0 and 20 m) depths. Gradients are generally slight, indicating that the water column is well mixed (Table 4).

Ammonia: Ammonia is excreted by marine organisms at all levels of the food chain, from zooplankton to marine mammals. It is also a by-product of decomposition and is used as a food source by some plankton. Within the ASBS, ammonia concentrations and fluctuations appear to be the result of such biological activity.

Upwelling causes an increase in surface ammonia values by fostering the growth of phytoplankton populations, which in turn leads to increased zooplankton activity. Therefore, increases in nutrient concentration should be followed by a similar elevation in ammonia concentration, allowing for a time lag and some horizontal displacement. Lasley (1977) found that ammonia values in the south bay remained low during the first few days after upwelling ceased, then increased to 7.8 mg-at/1 with highest values towards Pt. Pinos. The entire gradient moved eastward, then subsided, undoubtedly indicating the movement of a greater surface population of zooplankton.

The average ammonia concentration at CALCOFI Station 1, about 1/4 mile offshore from the ASBS, was 1.67 mg-at/1 between 1972 and 1976. During the AMBAG 1971-72 survey, the average ammonia value at this station was 23 times the average value at the Pt. Pinos station. It was hypothesized that the high values at Station 1 were due to the proximity of sewage discharges; however, this was probably not the case as values at stations closer to the outfalls remained low. The higher values were probably the result of greater zooplankton activity in an area where upwelled water had slowed down and warmed somewhat. The higher values could also be attributed to the bird and marine mammal populations which are much more prevalent on the rocks inshore from CALCOFI Station 1 than at Pt. Pinos, particularly during the summer when the discrepancy in ammonia values was greatest. The sharp, usually negative gradient in concentrations also suggests that differences are related to biological activity.

One rather interesting feature of the CALCOFI ammonia data is the long term decrease in values, from an average of 3.61 mg-at/1 in 1972 to 0.46 mg-at/1 in 1976. This 85% reduction could not be attributed to decreased sewage discharges or improved treatment; neither occurred significantly during this five year period. The decrease could partially be attributed to an improvement in laboratory technique and method of analysis. However, the sampling time also changed from early morning (about 8:00 a.m.) to random hours of the day or night, which may account for some of the decrease in values. Generally speaking, zooplankton migrate vertically to surface waters during the early evening, then subside at daylight. Thus, one would expect the maximum ammonia concentrations resulting from zooplankton activity in the early morning, when the earlier years' sampling was done. Differences in sampling time might also account somewhat for the disparate ammonia values at the AMBAG and CALCOFI 1 stations, as the AMBAG station was sampled at various times of the day.

Topographic and Geomorphic Characteristics

Submarine Topography: The ASBS is located in Monterey Bay, a wide-mouthed, deep bay which is bisected by an extensive submarine canyon. The canyon, as delineated by the 100-fathom curve, occupies 19 percent of the Bay's area. It drops off most steeply near shore and is 100 fathoms deep only 1.5 miles (2.4 km) offshore. At the mouth of the bay the canyon is about 450 fathoms deep and 5 miles (8.0 km) wide.

The canyon is aligned in a northeast-southwest direction, so at the mouth of the Bay the canyon is much closer to the southern headlands (4.1 miles, 6.5 km) than it is to Santa Cruz, at the north end of the Bay. The south canyon wall is also steeper, dropping from 100 to 900 fathoms in 1-1/2 miles (2.4 km) off Pt. Pinos.

The ASBS lies within the southern "shallows" of the bay, a water area enclosed by the Monterey Peninsula on the west side. Within the ASBS, depth contours are more compressed than in the rest of the southern shallows. The 40 fathom curve is one mile (1.6 km) offshore at Pacific Grove, but 3 miles (4.8 km) offshore at Monterey.

The subtidal topography of the ASBS consists of shallow water reefs, interspersed with fields of coarse-grained sand. Kelp beds generally mark the location of reefs during the summer. There are also numerous shallow submerged rocks in the ASBS near Pt. Pinos, Lucas Point (Aumentos Rock), Lovers Point and Point Cabrillo.

Geophysical Characteristics: The ASBS is located at the northern end of the Santa Lucia Mountains, where these mountains descend beneath Monterey Bay. The geology of the shoreline and nearshore waters of the ASBS is relatively simple, consisting only of Santa Lucia granodiorite.

The granodiorite intruded into the older Sur Series rocks in late Cretaceous time, about 80 million years ago. At Pacific Grove the granodiorite is porphyritic, containing large crystals of feldspar imbedded in a finer-grained groundmass of quartz, feldspar and boitite mica. The rock is highly fractured and therefore weathers easily to sand size particles.

The rock mass is cut by dikes, which are somewhat more resistant to weathering than the granodiorite. The rocks are extensively jointed in several directions, the most persistent being parallel to the shoreline. Jointing frequently occurs perpendicular to this, thus producing a blocky pattern in the exposed outcrops best seen at Lucas Point and Otter Point.

The sandy beaches within and adjacent to the ASBS are derived entirely from the granodiorite. Arnal, et al. (1973) note that Monterey Bay is a closed system with no sediment being transported into or out of the bay to the north and south. Also, the shoreline at Pacific Grove is situated such that longshore transport into the area from south bay beaches is highly unlikely.

The cliffs above the ASBS consist of finer grained marine terrace deposits, which may contribute sediment to the ASBS during periods of runoff and in areas of erosion. However, throughout the survey area, portions of the terrace are protected by a granite rock seawall.

The seawall appears to be well-constructed and in good condition. It is important in maintaining water clarity in the ASBS and in preventing excessive siltation which could cover and smother sessile organisms.

Stairways and steps built into the seawall also mitigate erosion by providing a safer, easier means of reaching the intertidal zone. Paths are less common, and cliff erosion generally less severe in areas where seawall and stairways have facilitated access.

The only somewhat natural drainage into the ASBS is from Greenwood Creek which runs through Greenwood Park. Upstream from the park, the creek again becomes part of the storm drain system. All other freshwater discharges to the ASBS are from storm drains.

Climate

The ASBS lies within the latitudinal range dominated by the Pacific High pressure cell, a clockwise-moving gyre with its center at about 40°N latitude. The proximity of this high pressure cell to the California coast is responsible for large-scale weather patterns within the ASBS.

Rainfall is moderate within the ASBS and highly seasonal. Between 1972-75, average rainfall was 16.3 in. (41 cm) at Pacific Grove (Table 5) and 86% of the total occurred between November and April. The persis-

TABLE 5: WEATHER DATA: PACIFIC GROVE MARINE GARDENS FISH REFUGE AND HOPKINS MARINE LIFE REFUGE ASBS

MONTH	Average High Temperature For Month (PGTP; 1972-76)	Average Low Temperature For Month (PGTP; 1972-76)	Range Between Ave. Low & High Temperatures (PGTP; 1972-76)	% Overcast Mornings (PGTP; 1972-76)	Average Daily Humidity (HMS; 1973)	Average Rainfall (PGTP; 1972-75)	Monthly Range of Rainfall (PGTP; 1972-75)	Average Wind Speed (HMS; 1973)	Monthly Range in Wind Speed (HMS; 1973)	Percentage of Days With No Wind (HMS; 1973)
JANUARY	65.2	40.6	24.6	47.1%	78.3%	2.9"	.6 - 5.3"	4.8 MPH	0 - 30 MPH	32%
FEBRUARY	66	42.6	23.4	64.1%	86.4%	2.8"	.6 - 6.1"	4.4 MPH	0 - 13 MPH	27%
MARCH	68	43.4	24.6	55.5%	78%	2.9"	0 - 4.6"	11.1 MPH	0 - 40 MPH	13%
APRIL	71.8	46.8	25	54%	77.9%	1.1"	0 - 2.4"	21.0 MPH	0 - 35 MPH	15%
MAY	74.2	51.2	23	67.7%	81.8%	0	---	8.5 MPH	0 - 20 MPH	6%
JUNE	76	52.6	23.4	67.3%	78.9%	.15"	0 - .4"	9.9 MPH	0 - 26 MPH	10%
JULY	76.2	54.8	21.4	81.3%	79.7%	.1"	0 - .3"	7.6 MPH	0 - 19 MPH	18%
AUGUST	74	56.8	17.2	84.5%	84.9%	0	---	2.4 MPH	0 - 15 MPH	19%
SEPTEMBER	74	55	19	77.3%	80.5%	.05"	0 - .2"	7.1 MPH	0 - 20 MPN	17%
OCTOBER	74	50.8	23.2	56.8%	83%	1.9"	1.4 - 2.6"	4.9 MPH	0 - 19 MPH	35%
NOVEMBER	69	46.8	22.2	40%	81.8%	2.4"	.6 - 4.6"	3.8 MPH	0 - 28 MPH	35%
DECEMBER	64.8	41.6	23.2	43.9%	84.5%	2.0"	.4 - 3.2"	2.1 MPH	0 - 12 MPH	32%
TOTALS/ AVERAGES	Average 71.1	Average 48.6	22.5	61.6%	81.3%	Total 16.3"	Total 0 - 6.1"	7.3 MPH	0 - 40 MPH	

tence of the Pacific High almost totally excludes rainfall during the summer. The "rainy season" begins whenever the Pacific High is dislodged; this can occur as early as September, or as late as January. The length of the rainy season is also highly variable, such that March and April can experience the heaviest rains, or no rain at all.

Wind direction varies seasonally with the location of the Pacific High pressure cell. When this cell is centered over the North Pacific, generally between April and September, the coast catches the eastern edge of the gyre, and prevailing winds are from the northwest. In Monterey, prevailing winds are from the north or northwest over 58% of the time in the spring and summer (Scott 1973). The strongest northwest winds usually occur in March and April. During the winter, the Pacific High is frequently dislodged by low pressure systems, in which atmospheric rotation is counterclockwise. Thus, winds accompanying such storm fronts will be from the south, southwest or southeast, depending upon the direction of the storm's approach. Northerly winds occur as the storm front passes eastward, and represent the western side of the counterclockwise moving gyre. Prevailing winds are still from the northwest, north-northwest or north more than 47% of the time, (Scott 1973) but are generally weaker than in spring and summer.

Air temperatures in the ASBS are moderate and show little diurnal or seasonal variation. The average annual maximum temperature is 71.1°F (21.7°C); the average annual minimum temperature is 48.6°F (9.2°C) (see Table 5). The proximity of both the bay and the ocean serves to moderate fluctuations in nearby land temperatures. The afternoon sea breeze keeps maximum temperatures down, whereas the evening fog traps heat radiated off the land and prevents early morning temperatures from dropping further.

Fog is a characteristic feature of Pacific Grove weather, particularly in the late spring and summer. During this period, a low-lying fog bank generally persists in the area with only short afternoon breaks. Fog is most prevalent in July, August, and September (Table 5).

Fog is a highly localized phenomenon. Its occurrence is related to that of upwelling, which creates a maximum range between air temperatures over land and water. Fog formation is least common during the fall, when warmer oceanic water invades nearshore areas.

BIOLOGICAL DESCRIPTION

Subtidal Biota

The subtidal zone was surveyed using six line transects evenly spaced throughout the ASBS. Of these, four were sixty meters long and two were 340 meters long. The locations of the transects, survey dives and sand samples are shown in Figure 2.

The subtidal survey was conducted in the fall (October 7, 1977 to November 22, 1977). The first winter storm, bringing unusually large waves, occurred midway through the survey (October 28, 1977). This provided the opportunity to record some of the effects of the storm on the kelp and bottom community. These are discussed in the following transect descriptions and summarized in the subtidal discussion.

The transect descriptions begin with Green Gables, the easternmost transect, and continue to the Point Pinos transect at the western boundary of the ASBS. A description of the biota in the vicinity of the Pt. Pinos outfall (.4 miles, or .6 km west of the ASBS) is also included. Appendix 1 summarizes the distribution and relative abundance of the common algae, invertebrates and fish recorded on these transects.

Green Gables Transect: Green Gables was surveyed in November, 1977. Kelp beds were observed relatively close to shore in shallow water. Along the gently sloping bottom (6 foot drop in 60 meters) low rocks and sand were interspersed with about a 4:1 ratio of rock to sand cover. Fewer rocks and more sand bottom appeared to continue offshore.

There was conspicuous and widespread evidence of scouring, especially in channels perpendicular to shore where coarse sand, broken sand tube dwelling polychaete *Phragmatopoma californica* tubes, and shell fragments collected. Many rocks appeared barren of encrusting forms and literally sandblasted.

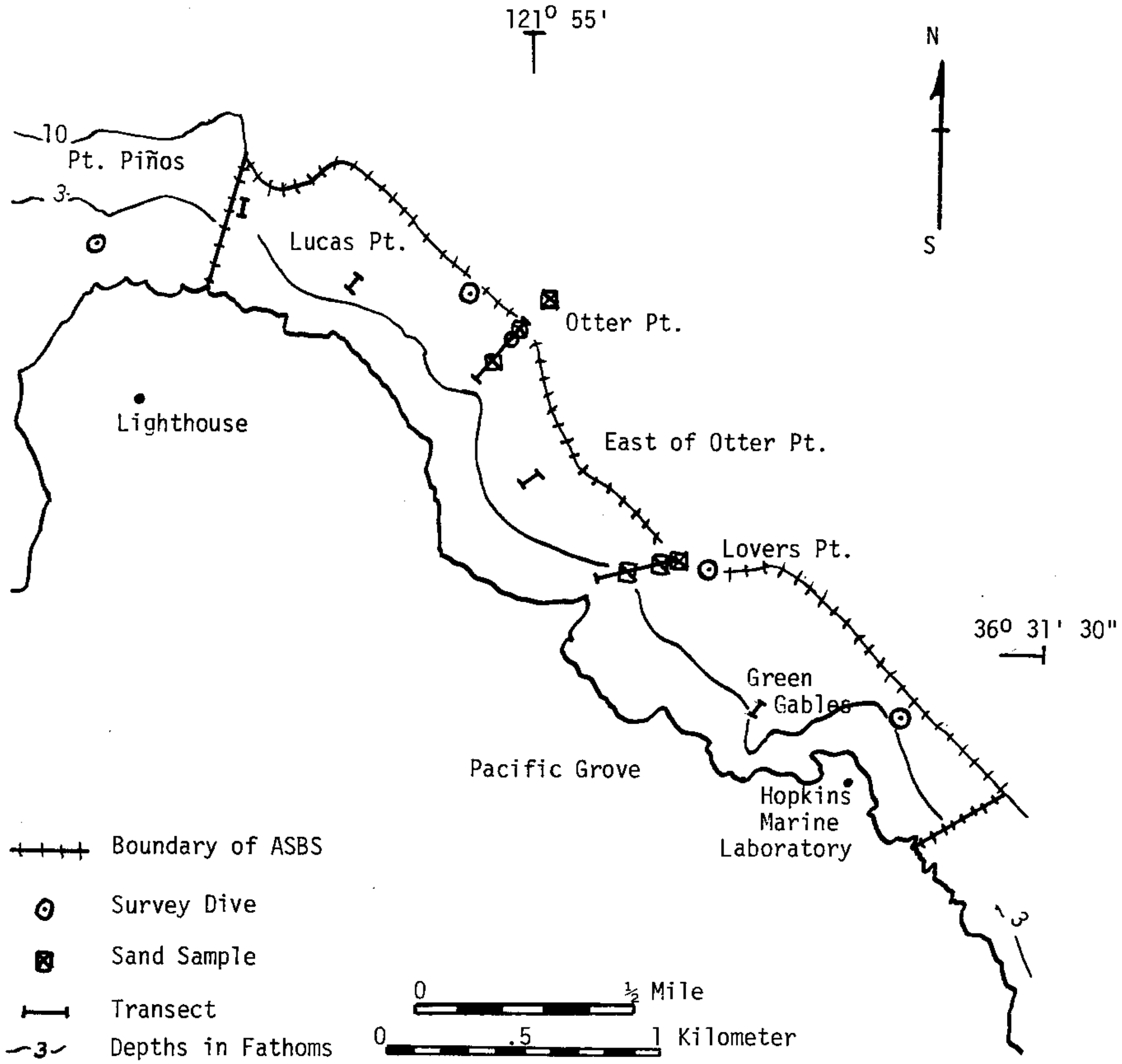

Figure 2: Location of survey dives, transect lines, and sand samples in ASBS.

On the first dive to the area, giant kelp, Macrocystis pyrifera, was noted as abundant; however, only four intact plants remained along the transect after the first winter storm. Each plant displayed an average of four stipes. Blades and pneumatocysts were torn from the plants leaving stipes tangled on the bottom. Despite this severe storm damage, growing tips were seen on most of the remaining kelp plants. Bare patches of rock encircled by haptera fragments and several giant kelp holdfasts without stipes were indicative of the former kelp densities along this transect.

The dominant understory algae along the transect were Rhodymenia spp. and Gigartina spp. Laminaria dentigera occurred only at the shallow end of the transect, while Cystoseira sp. was more abundant in deeper water. Callophyllis spp. and articulated corallines were moderately common along the entire length of the transect. Plocamium cartilagineum, Botryoglossum farlowianum and red point were scarce. Laminaria dentigera, Dictyoneuropsis reticulata, and Plocamium cartilagineum all sustained obvious damage from the storm. However, Cystoseira sp. and most of the common red algae did not appear damaged.

Among the invertebrates, the sand tube building polychaete, Phragmatopoma californica, and the colonial tunicate Archidistoma psammion provided the dominant cover on rocks in the first 82 ft. (25 m) of the transect. Low encrusting colonies of Phragmatopoma accounted for up to 60% of the cover on some rocks.

The red sponge Acarnus erithacus occurred in small patches towards the deep end of the transect. The sponge Tethya aurantia was common; several extensive colonies occurred on one large rock. Small colonies of Hymenamphiastra cyanocrypta and other unidentified sponges were present in crevices.

Of the three species of corals, Balanophyllia elegans was most common; small individuals were scattered throughout the entire length of the transect. Astrangia lajollaensis was scarce, occurring only under ledges or overhanging rocks.

The hydroids Abietinaria spp. and Sertularella sp. occurred on large rocks in low numbers.

The polychaete Dodecaceria fewkesi was present, forming crusts on rock faces in the shallow half of the transect. Diopatra ornata formed dense beds in channels and sand patches in the mid portion of the transect. In many of these beds, the Diopatra ornata tubes were stripped clean of attached material and appeared collapsed. The feather duster, Eudistylia polymorpha, was present in low numbers. The tube dwelling snail, Petaloconchus montereyensis, was scarce, occurring only as small colonies or as solitary individuals. The gumboot chiton, Cryptochiton stelleri, was unusually common, with 15 large individuals occurring along the transect.

Coinciding with the reduction of the Macrocystis canopy after the storm was a great increase in the density of turban snails on the bottom. Hundreds of snails, mostly Tegula montereyi and T. pulligo, had been shaken loose or bailed out of the canopy. Many of these were clustered on Laminaria dentigera and other understory algae. One red abalone was found, inhabiting a crevice.

Social tunicates, Pycnoclavella stanleyi, were present as small isolated colonies in the first 66 ft. (20 m) of the transect. Other tunicates present inshore included the stalked tunicate, Styela montereyensis, and Didemnum carnulentum. In the last half of the transect, the abundance of all the tunicate species dropped, coinciding with the increase in sand and decrease in rock bottom. The occurrence of the ascidian, Cystodytes lobatus, in the latter portion of the transect is consistent with its appearance at similar depths in other transects.

There was almost a complete absence of erect bryozoan thickets growing on the rocks. Cryptosula pallasiana and other encrusting bryozoan species predominated. Costazia robertsonae and Lagenipora sp., typically erect branching forms, were growing in low flat colonies. Hippodiplosia insculpta, where it occurred, was growing on red algae and was not found in the large frilly colonies common in deeper water.

Arthropods present included barnacles, Balanus sp., as a sparse cover, and various species of decapods, including large kelp crabs, another canopy dweller.

The bat star was common throughout the transect, aggregating in channels and along the edges of rocks. The star fish, Pisaster giganteus, was common on rocks. Three sunflower stars, Pycnopodia helianthoides, were present in the first 66 ft. (20 m) of the transect.

Three species of surfperch were observed; the black surfperch, Embiotoca jacksoni, the striped surfperch, E. lateralis, and the pile surfperch, Damalichthys vacca. Juvenile rockfish occurred in large mixed aggregations dominated by blue rockfish, Sebastes mystinus. One kelp greenling, Hexagrammos decagrammus, was counted along the transect. Other fish seen during the day included the black and yellow rockfish, S. chrysomelas, and the cabezon, Scorpaenichthys marmoratus. The convict fish, Oxylebius pictus, was common, particularly among the articulated corallines. Refer to Appendix 2 for a schematic drawing of the Green Gables transect.

The Lovers Point Transect: This area was surveyed during October, 1977, and is characterized by an inshore rocky reef, followed by a sand plain 330 ft (100 m) in length and then another rocky reef offshore. The transect had a high proportion of sand (43%) and, in the rocky reef areas, sand was interspersed throughout. The kelp canopy showed an obvious break over the sand plain visible from a boat or shore. Giant kelp, Macrocystis pyrifera, density was highest inshore; 18 plants were counted on the inshore reef compared with five plants on the offshore reef.

The most abundant algae inshore were Gigartina spp. and Callophyllis spp. The brown alga Cystoseira osmundacea was common throughout the length of the transect and occasionally abundant inshore. Desmarestia ligulata var. ligulata was present on both the inshore and offshore reefs.

Fleshy red algae, mostly Callophyllis spp. and Rhodymenia spp., were less common on the offshore reef; articulated and encrusting corallines became more prominent.

Two somewhat isolated rocks in sandy areas supported a large number of algal species in unusually high densities. Reduced grazing might explain this phenomenon, as the sand could act as a barrier to herbivores. If so, this suggests that grazers play an important role in determining algal densities in this area.

The red sponge, Acarnus erithacus, grew in conspicuous patches throughout the transect but was never a dominant species. The yellow finger sponge, Polymastia pachymastia, was found on the low rocks adjacent to sandy areas in offshore reefs only.

Several coelenterates showed distinct patterns of distribution with depth along this longer transect. Whereas the social coral, Astrangia lajollaensis, and the aggregating anemone, Anthopleura elegantissima, were found predominantly inshore, the coral Paracyathus stearnsi and the anemone Tealia lofotensis were both more common offshore. The red strawberry anemone, Corynactis californica, occurred on both inshore and offshore reefs and was most common on vertical high rock faces.

Abietinaria spp. and Sertularella sp. were the most obvious of the hydroid species and were common throughout the length of the transect. In one particular area, these two species replaced the bryozoan Hippodiplosia insculpta in a circle around the base of giant kelp plants. The abrasive action of the plant's sporophyll blades apparently favored the existence of the more flexible hydroids. A nudibranch, Trinchesia lagunae, which feeds on hydroids, was found laying coils of spiraled egg masses on the colonies.

The tube building polychaete, Dodecaceria fewkesi, was present at both reefs, but the mound-shaped colonies were more characteristic of the deeper reef. The crust building polychaete was not as common as at other sites. Other polychaetes included Salmacina tribranchiata, which grew in small colonies on rock faces and the feather duster, Eudistylia polymorpha, which was rather scarce.

The tube worm, Diopatra ornata, occurred in sandy areas adjacent to rock and formed enormous beds at two points along the inshore portion of the transect. The slender white tentacles of the terebellid polychaete, Thelepus crispus, were extended over the surface of the tubes. The bat star, Patiria miniata, was common in these Diopatra beds.

Burrow openings of the lugworm Abarenicola sp. were scattered throughout the sandy bottom. Occasionally the large, gelatinous egg masses were observed protruding from these burrows.

The bryozoan Hippodiplosia insculpta was an important cover species, particularly in the high relief area at the outside edge of the shallow water reef. This species occurred on the tops of rocks and was seen occasionally near the top of vertical faces, often growing on algae or in a thicket mixed with other bryozoans. The erect calcareous bryozoans Costazia robertsonae, Lagenipora sp., Hippothoa hyalina and Phidolopora pacifica were important cover on rock faces throughout the length of the transect. The delicate arborescent bryozoans, Scrupocellaria sp. and Thalamoporella sp., were also seen along the transect. Encrusting bryozoans were widespread, occurring both on low rocks and on patches on taller rocks.

The bat star was ubiquitous even on sand areas. The common starfish, a species restricted to rocks, was the second most abundant species of sea star.

The strikingly white translucent tunicate, Cystodytes lobatus, formed large colonies on rock tops in the offshore reef kelp bed. This species was preyed on by the giant keyhole limpet, Megathura crenulata.

The brown colonial tunicate, Archidistoma psammion, was common throughout, occurring in small circular patches. The large solitary tunicate, Styela montereyensis, was sparse on the inshore reef and otherwise absent.

Juvenile blue rockfish, Sebastes mystinus, were common everywhere, occurring with other juvenile fish. Schools of the juvenile bocaccio, Sebastes paucispinus, were noted above the inshore reef. Kelp rockfish, S. atrovirens, were seen at the outer portion of the inshore reef and on the offshore reef.

Surfperch associated with the rocky reefs included the rainbow surfperch, Hypsurus caryi (inshore only), pile surfperch, Damalichthys vacca, and black surfperch, Embiotoca jacksoni. Refer to Appendix 2 for the schematic drawing of the Lovers Point transect.

Moribund sunfish, Mola mola, were seen on the bottom at the outside reef. Some were still feebly moving, though they had attracted numerous bat stars which had begun to feed on the dying fish.

Otter Point (EAST) Transect: Otter Point was surveyed October 22, 1977. It is somewhat sheltered from northwest swells. A large, dense kelp bed was present at the time of the survey; twelve kelp plants were counted along the transect, with an average of 18 stipes per plant. This transect was completed before the first winter storm, which partially accounts for the differences in kelp density between this location and the Green Gables transect, another semi-protected area.

Though the rugged, blocky topography seen onshore continued into the subtidal zone, much sand had accumulated and occupied approximately one fourth of the transect length. The topographical similarities between this area and the Green Gables transect were reflected in a similarity of the flora and fauna.

Gigartina spp. were the most common understory algae, followed by Callophyllis spp., Rhodymenia spp. and Botryocladia pseudodichotoma. The brown algae Cystoseira osmundacea and Dictyoneuropsis reticulata occurred throughout the transect. Filamentous red algae, primarily Antithamnion sp. and Tiffaniella sp., were found occasionally, occurring as delicate sandy turfs on rocks.

The overall impression of the invertebrates was of a very mixed cover, no doubt influenced by the varied substrates which included sand, low rocks and tall granite blocks.

The polychaete Diopatra ornata occurred in sparse colonies in the sand patches, its parchment tubes providing a habitat for several species of red algae. Both the encrusting and the tube building polychaete Dodecaceria fewkesi were found. The fan worm, Myxicola infundibulum, with its light green crown of feathery tentacles, was common in crevices. A tube snail, Petalochonchus montereyensis, occurred throughout the transect and covered up to 50% of some nearshore rocks.

Rainbow sea perch, Hypsurus caryi, were the most numerous adult fish seen on the transect. The pile surfperch, Damalichthys vacca, and one black surfperch, Embiotoca jacksoni, were also present. Juvenile blue rockfish, Sebastes mystinus, were very common. A large male cabezon, Scorpaenichthys marmoratus, was observed guarding eggs behind a pair of granite blocks.

The pattern of invertebrate and algal cover on the 6-1/2 to 8 foot high granite blocks was noteworthy. Rock faces parallel to the direction of the swell were almost covered by small barnacles and supported a few scattered colonies of the bryozoans, Phidolopora pacifica, Costazia robertsonae, and Didemnum carnulentum. Small Rhodymenia sp. were the only algae observed. The inner sides of the rocks were covered by a dense carpet of the coral Astrangia lajollaensis, over a square meter in area on each face. The tops of the rocks supported a diverse assemblage: Dense growths of Gigartina sp. and other red algae and the invertebrates Corynactis californica, Phragmatopoma californica, Hippodiplosia insculpta, Costazia robertsonae, scattered Balanophyllia elegans, and erect heads of the bryozoan Hippothoa hyalina. Refer to Appendix 2 for the schematic drawing of the transect east of Otter Point.

Otter Point Reef Transect: The rocky reef at Otter Point was surveyed in November, 1977, and was found to be comprised of rocks, boulders, and pinnacles extending out 690 feet (210 m) to a depth of 40 feet (12 m). A sand plain extended to the end of the transect.

Kelp was reduced, although a thin canopy was visible on the surface. Fourteen adult Macrocystis plants averaging seven stipes per plant were counted on this transect compared with 23 plants on the long transect at Lovers Point. Noteworthy was the occurrence of eight small juvenile plants. The increased light available with the reduced canopy will no doubt facilitate the growth of these new plants.

Algal cover dominated the inshore portion of the transect. Most available rock surfaces were covered with a carpet of Gigartina spp., Rhodymenia spp. and Cystoseira osmundacea. Though these species continued to be common, algal cover markedly decreased by a depth of about 20 feet (6.1 m).

Neoptilota densa and delicate sycophant, Microcladia coulteri, common in the shallow water at Otter Point, were not seen on any of the other deeper transects. Red point, Prionitis australis, was also collected only at this site.

The scattered rocks in the offshore sand plain were the deepest rock substrata examined. Filamentous red algae were common on all rocks, mixed with worm tubes and loose sand grains. Gigartina spp., Rhodymenia spp., red point, and Grateloupia doryphora were all seen on these deeper rocks. Though kelp could be seen at this depth on rocks in the distance, no adult plants occurred within the transect.

Encrusting bryozoans and tunicates were the most common invertebrates under the dominant algal cover inshore. As algal cover decreased, erect calcareous bryozoans and other invertebrates became more common. Rock faces and crevices harbored a more diverse invertebrate cover throughout.

Scattered colonies of sponges occurred along the transect. The yellow finger sponge, Polymastia pachymastia, was only noted on the offshore sediment-covered rocks.

The solitary coral, Balanophyllia elegans was the most common and widely distributed coelenterate at Otter Point. The large cup coral, Paracyathus stearnsi, was found only in the deepest part of the transect. Only two small colonies of the social coral, Astrangia lajollaensis, were seen.

The anemones Anthopleura elegantissima and Epiactis prolifera occurred in the shallow inshore area. A. elegantissima was abundant in sand and gravel between cobbles. The small red anemone, Corynactis californica, was common on rock faces in all depths. Various species of the anemone, Tealia, were conspicuous on rock faces offshore.

Abietinaria spp. and Sertularella spp. were the most common hydroids on rocks, and were particularily abundant on the faces and tops of pinnacles. On red algae and the brown algae, Cystoseira osmundacea, the hydroids Aglaophenia sp., Sertularia sp., and Eucopella sp. predominated.

The crust forming polychaete, Dodecaceria fewkesi, was common inshore but was never dominant as it was at Lucas Point and Pt. Pinos. The large tube building form of D. fewkesi occurred in scattered heads on rock tops. The tubed worms, Phragmatopoma californica, grew in patches on rocks in shallower water. Small colonies of the tube dwelling snail, Petaloconchus montereyensis, were common in the inshore half of the transect, sometimes mixed with Phragmatopoma.

Juvenile bocaccio, Sebastes paucispinus, were seen several times along the transect. Juvenile blue rockfish were very common around the rocky portions of the transect. Also seen were kelp rockfish, S. atrovirens, and kelp greenlings, Hexagrammos decagrammus. Pile surfperch, Damalichthys vacca, black surfperch, Embiotoca jacksoni and striped surfperch, E. lateralis, were also seen. See Appendix 2 for the schematic drawing of the Otter Point Transect.

Lucas Point Transect: Both Lucas Point and Pt. Pinos provided a contrast to the more protected sites to the southeast. Lucas Point area was surveyed November 2, 1977. These westerly transects occur in a surf swept, high energy zone exposed to the force of the open sea.

Tall granite outcrops and boulders were occasionally interrupted by pockets of coarse sediment which constituted about 8% of the transect length. The lack of fine sediment contributed to improved water clarity.

Although this transect was surveyed after the first large winter storm, a substantial kelp canopy still remained. Four Macrocystis pyrifera plants, averaging 18 stipes per plant, were noted in the sixty meter swath. Spots where whole Macrocystis plants had been dislodged were also evident.

As fewer fragile organisms normally occur in the area, storm effects on the biota were not as obvious as at Green Gables. However, thick drifting kelp and overturned boulders were suggestive of the force of this storm.

The red algae, Botryoglossum farlowianum, was very abundant along the entire transect. Botryoglossum and another red algae, Gigartina corymbifera, formed a dense algal understory covering most flat rock surfaces. Low-lying small boulders tended to be depauperate except for occasional Botryocladia pseudodichotoma, crustose red algae, encrusting bryozoans, and the ubiquitous encrusting coralline algae.

Encrusting corallines covered about 50% of available rock surfaces and gave a pink cast to the rocks. Articulated corallines were very common. Both the articulated corallines and the foliose red algae were much larger, denser, and less encrusted than the same groups at the more easterly sites.

Increased water clarity as well as reduced grazing by invertebrates at Lucas Point could be factors contributing to this lush algal growth.

Certain animal species showed notable increases in density at this site. The crust building polychaete, Dodecaceria fewkesi, covered nearly all stable rock formations under a thin layer of encrusting coralline algae. Likewise, the plumed sabellid worm, Eudistylia polymorpha, was seen in nearly all available crevices.

Sponge cover was sparse; only Hymenamphiastra cyanocrypta occurred commonly throughout. Tethya aurantia and several unidentified species were also seen.

The coral, Balanophyllia elegans, was abundant throughout the transect. However, the social coral, Astrangia lajollaensis, common at more protected sites, occurred only once. A delicate and uncommon octocoral, Clavularia sp., grew in small colonies on rock faces.

An anemone, Tealia coriacea, with adherent tubercules which cling to sand and gravel, was observed only at Lucas Point, where it was found in depressions with sand and gravel. Also commonly occurring in these depressions was the aggregating anemone, Anthopleura elegantissima. In the deepest half of the transect, Tealia lofotensis was the most common anemone. Aglaophenia spp., Plumularia spp., Eucopella sp. and Abietinaria spp. were among numerous species of hydroids growing on algae.

Among the molluscs, the lined chiton, Tonicella lineata, was conspicuous feeding on coralline crusts. The chitons Lepidozona sp., Mopalia sp. and several Cryptochiton stelleri were also observed. Mitra idae, a predatory gastropod, occurred frequently. As at Green Gables, many turban snails, Tegula spp., displaced from the kelp canopy, were seen on the bottom.

Encrusting bryozoans, especially Cryptosula pallasiana, and an unidentified orange species were much more in evidence than the thicket forming bryozoans, of which only Costazia robertsonae commonly occurred at this site. The bat star, Patiria miniata, and Pisaster giganteus were common to abundant at Lucas Point.

Styela montereyensis was the most conspicuous tunicate here. Another solitary form, Ascidia ceratodes, was seen in two small patches. A. ceratodes was only observed here and at Pt. Pinos. Other tunicates included Didemnum carnulentum, Archidistoma psammion, common in small colonies, and scattered colonies of Trididemnum opacum on vertical rock faces. Disintegrating colonies of T. opacum were observed.

Señoritas, Oxyjulis californica, were common at Lucas Point. Normally a canopy dweller, their appearance on the bottom may be related to a reduction in kelp canopy habitat.

Other fish seen on the transect included juvenile blue rockfish, Sebastes mystinus, juvenile bocaccio, S. paucispinus, black surfperch, Embiotoca jacksoni, and the kelp greenling, Hexagrammos decagrammus. Appendix 2 contains schematic drawings of the Lucas Point transect.

Point Pinos Transect: The historical site of many shipwrecks, Pt. Pinos is characterized by a dramatic submarine topography and extreme exposure. This area was surveyed October 21, 1977. Large smooth boulders and piles of rocks were interspersed along the steeply sloping transect. A small amount of coarse gravel was the only loose sediment to accumulate in this high energy area (Figure 3).

The kelp bed present at this site was extensive and extended into deeper water than at other sites. The typically open coast bull kelp, Nereocystis leutkeana, was a visible component of the giant kelp, Macrocystis pyrifera, dominated canopy.

Along most of the transect, articulated and encrusting corallines were the dominant algal cover; foliose red algae were occasionally found on rock tops. The red algae, Gigartina corymbifera, occurred near the inshore edge of the transect and, about midway through the transect, a large flat rock supported locally dense foliose red algae. Callophyllis sp. was dominant, and mixed with Plocamium cartilagineum, Prionitis lanceolata and Botryocladia pseudodichotoma.

The brown algae Dictyoneuropsis reticulata, Cystoseira osmundacea and Laminaria dentigera occurred only sparsely. One specimen of red algae, Weeksia reticulata, typical of exposed coasts, was found at this site.

The invertebrate cover closely resembled that at Lucas Point, with extensive crusts of the polychaete Dodecaceria fewkesi and high numbers of crevice dwelling feather duster worms, Eudistylia polymorpha. Encrusting sheets of bryozoans, sponges and low growing colonial tunicates predominated.

Hymenamphiastra cyanocrypta and Cliona celata were the most widespread sponge species. Also observed but much less common were Tethya aurantia, the red sponge, Acarnus erithacus, and three or four unidentified species.

While the solitary coral, Balenophyllia elegans, was widespread at Pt. Pinos, Astrangia lajollaensis (common at the protected sites) was absent. The serpulid polychaete, Salmacina tribranchiata, was also seen; the sessile snail, Petaloconchus montereyensis, was scarce, growing in tight low mounds on the rocks.

The two dominant bryozoans were encrusting forms, Cryptosula pallasiana and an unidentified orange species. Small colonies of the branching calcareous bryozoans Costazia robertsonae, Lagenipora sp., and erect colonies of Hippothoa hyalina were seen occasionally on rock faces.

Pt. Pinos shared with Lucas Point a clean appearance resulting from the lack of loose sediment and extensive cover of encrusting coralline algae. However, the more extreme exposure of Pt. Pinos was reflected in the comparatively sparser cover by red algae and sessile invertebrates.

Large rockfish were frequently observed here. This is the only transect where adult blue rockfish, Sebastes mystinus were seen. A large cabezon, Scorpaenichthys marmoratus, appeared to be maintaining a territory in one area of the transect, though no nest was seen. Two species of surfperch were noted on the transect, black surfperch, Embiotoca jacksoni, and pile surfperch, Damalichthys vacca. Appendix 2 contains schematic drawings of the Pt. Pinos transect.

Point Pinos Outfall Survey Dive: One survey dive was made in September, 1977, in the cove to the south of Point Pinos, where the Pacific Grove sewage outfall is located. Poor visibility (less than three feet), suspended particulate material and a penetrating foul smell characterized the water in the vicinity of the outfall. Coarse sand and several partially buried Pterygophora californica plants in the cove reflected the intense water movement and scouring in the area.

Giant kelp, Macrocystis pyrifera, did not occur until outside the cove, beginning in a depth of 45 feet (14 m). However, suitable substrate occurred at shallower depths. Visibility beyond the cove was much improved (20 to 40 feet or 6 to 12 m). Pterygophora californica occurred both within the cove and under the giant kelp canopy. Botryoglossum farlowianum and Callophyllis sp. were important algal species in the kelp bed. One specimen of Opuntiella sp. was collected.

Conspicuous invertebrates in the kelp bed included the encrusting colonial tunicates Didemnum carnulentum and Aplidium sp. and the massive sponge Stelletta clarella. Petaloconchus montereyensis formed large colonies on some vertical rock faces. The fauna and flora beyond the point were diverse and appeared healthy.

Pearse and Weaver (1971) noted in a reconnaissance dive that plant cover in the vicinity of the outfall was dense and seemingly healthy. However, they noted the following anomalies which may be significant.

1. Many Gigartina collected seemed deformed.
2. Sponges, tunicates and most animal species were sparse; however, the bat star, Patiria miniata, and the brown turban snail, Tegula brunnea, were exceptions.
3. The bat stars seemed small and those examined had no commensal worms.

Subtidal Survey Overview: Giant kelp, Macrocystis pyrifera, dominates the subtidal zone in terms of both structure and productivity. Some seasonal variation can be seen by comparing the May and September canopies. The kelp bed is most extensive at Pt. Pinos, paralleling greater availability of rock substrate (Appendix 6).

Kelp forests are extremely productive, at least equivalent in this regard to a terrestrial forest. Giant kelp has the highest rate of elongation of any plant (Aleem, 1973; Clendenning, 1961). This, combined with year round reproductive capacity, results in a high ability to regenerate after losses.

Of the primary producers, Macrocystis pyrifera contributes more than half of the yearly production. Dependent on this production, either directly through grazing, or indirectly through utilization of detritus and drift, are vermetids (and probably other important filter feeders), snails, abalone, the ubiquitous bat stars, sea urchins and crabs.

Seasonal and long term fluctuations cannot be evaluated from the reconnaissance survey and little information is available from the literature pertaining to central California. The importance of such fluctuations is suggested by the dramatic changes seen in the kelp bed after the storm which occurred midway through the survey. Storms appear to be the greatest single source of kelp plant loss.

The most obvious after effect of the storm was the greatly reduced kelp density. As shown in Table 6, the average number of plants and stipes was lower at sites surveyed after this storm.

The bull kelp, Nereocystis leutkeana, once an important part of the kelp canopy (particularily at exposed sites) is scarce in the ASBS. When Andrews (1945) studied this area there was a pure stand of N. leutkeana at Pt. Pinos, mixed M. pyrifera and N. leutkeana at Lovers Point, and only M. pyrifera at Point Cabrillo. Now the ASBS is dominated by M. pyrifera and N. leutkeana is seen only in the shallow portion of the Pt. Pinos kelp bed. Pearse (1974) alludes to this replacement of N. leutkeana and cites the sea otter as a likely factor. Miller and Giebel (1973) discuss this possibility and point out that the decline of N. leutkeana on the coast was widespread and occurred in areas not occupied by otters. Though the reduction in herbivores may have given M. pyrifera an edge in competition with N. leutkeana, this remains to be demonstrated experimentally.

Changes in patterns of algal abundance occur along a depth gradient from the surf zone to deep water and along an exposure gradient from the more protected Pt. Cabrillo to fully exposed Pt. Pinos.

The surf zone and shallow water areas are characterized by exceedingly dense and jungle-like plant growth. Surf grass, Phyllospadix

TABLE 6 . _Macrocystis_ _pyrifera_ (adult & juvenile) density, and average number of stipes at transects surveyed before and after October 28 , 1978 storm.

Transect	Relation to Storm	Adult Macrocystis	Average No. of Stipes	Juveniles
Green Gables (60 m)	After (11-1)	4	4	2
Lovers Point (340 m)	Before (10-7 to 10-17)	23	-	1
East Otter (60 m)	Before (10-22)	10	18	2
Otter Point (340 m)	After (11-8 to 11-11)	14	7	8
Lucas Point (60 m)	After (11-2)	4	13	0
Point Pinos (60 m)	Before (10-21)	7	24	0

scouleri, dominates large areas of the bottom, often interspersed with the ribbon kelp, Egregia menziesii. The ubiquitous kelp, Cystoseira osmundacea, dominates in this area in terms of numbers and biomass. In summer, the reproductive portions of this plant reach to the surface, where the bead-like vessicles form a canopy in shallow water. A census of this common plant is being taken in a current study of the Pt. Cabrillo kelp bed (Pearse and Hines, 1976). Faro (1969) described Dictyoneurum californicum, coralline algae, Ulva spp., Botryoglossum spp., Gigartina exasperata, G. corymbifera, and Iridaea flaccida as common in this zone. Animal cover is minimal here.

Devinny and Kirkwood (1974), with study sites at Lovers Point and Lucas Point, found the following 15 algal species only in the inshore and mid portion of the Monterey Peninsula kelp beds.

Ulva lobata
Callophyllis pinnata
Erythrophyllum delesseriodes
Gigartina exasperata
Iridaea cordata var. splendens
Laurencea spectabilis
Pterochondria woodii
Schizymenia pacifica
Bossiella californica var. californica
Bossiella chiloensis
Lithothamnion aculeiferum
Lithothamnion phymatodeum
Melobesia mediocris
Mesophyllum conchatum

Limited to the middle and outer portions of the beds were:

Desmarestia tabacoides
Dictyota binghamiae
Callophyllis firma

Polyneura latissima
Rhodoptilum densum
Rhodymenia callophyllidoides
Weeksia reticulata
Lithothammnium imitans

The Monterey Penninsula is noted for its rich algal flora. I.A. Abbott (in Smith and Carlton, 1976) estimates that 80% of the alga species of California can be found on the Monterey Penninsula. North (1971) comments that benthic subtidal algae tend to be more profuse and well developed in Central California kelp beds than to the south. Devinny and Kirkwood's short (1974) survey recorded 138 species here (94 within the ASBS); a greater number than were found during more extensive surveys in Southern California. The cool nutrient rich upwelled water in this region and relative lack of turbidity no doubt contribute to the richness and diversity of the flora.

The fifteen species listed below were most frequently encountered in benthic habitats in the ASBS.

Sponges:	Hymenamphiastra cyanocrypta
Coelenterates:	Astrangia lajollaensis
	Corynactis californica
Polychaetes:	Dodecaceria fewkesi
	Diopatra ornata
	Phragmatopoma californica
Molluscs:	Petalochonchus montereyensis
Crustaceans:	Balanus spp.
Bryozoans:	Costazia robertsonae
	Cryptosula pallasiana
	Hippodiplosia insculpta

Lagenipora sp.

Tunicates: Archidistoma psammion

Didemnum carnulentum

Tridemnum opacum

Juvenile blue rockfish were the most commonly observed fish in the transects. These fish, as juveniles, have been found to eat primarily hydroids, algal material and crustaceans. Other Juvenile rockfish species were also common. The juvenile rockfish first appear in the kelp beds in April and May and remain densely aggregated in the kelp areas until the winter storms, when they retreat to deeper water (Miller and Giebel, 1973). The kelp canopy appears to be a necessary requirement for the juveniles; experimental kelp harvesting resulted in a marked decline in population size. Pile surfperch, Damalichthys vacca, were the most common adult fish noted along the transects. The black surfperch, Embiotoca jacksoni, was also common, as was its congener, E. lateralis, associated with dense kelp stands. The largest fish in the area is the lingcod, Ophiodon elongatus, seen occasionally in the ASBS, and the cabezon, Scorpaenicthys marmoratus.

A large die-off of the sunfish, Mola mola, occurred during this survey at the end of September and beginning of October. Gotshall (1977) also notes this die-off of sunfish during the fall in Monterey Bay. The cause is evidently unknown.

The sighting of a cormorant, foraging along the transect at Lovers Point was also noteworthy. These sleek black birds feed exclusively on fish, including the blennies and sculpins common in crevices and around marine plants.

Intertidal Biota

The intertidal substrate of the ASBS consists of granite boulders and outcrops, interspersed with small, sandy coves. Stevenson and Stevenson (1972) described the range of exposure to which the intertidal area is subjected, as follows:

The high and mid intertidal zones on the rocks to the west contained primarily algal species; sea lettuce, Ulva spp., occurred in the highest areas, joined by Endocladia muricata, Gastroclonium coulteri, Gigartina leptorhynchos, crinkled sea rose, Rhodoglossum affine, Neoagardhiella baileyi and iridescent seaweed, Iridaea spp., at slightly lower levels. Patches of Chaetomorpha sp. were present, as was red point, Prionitis lanceolata.

The black turban snail, Tegula funebralis, was common in high sandy tidepools. The aggregating anemone, Anthopleura elegantissima, predominated at the base of rocks.

Lower intertidal habitat in this area was occupied almost entirely by surf grass, Phyllospadix scouleri, which was covered with diatomaceous filaments. Encrusting and upright corallines were abundant beneath the Phyllospadix.

As with the upper intertidal zone, invertebrates were a less conspicuous component of the biota. The bat star, Patiria miniata, was found frequently under algae and in small pools. The stalked ascidean, Styela montereyensis, occurred attached to sides of rocks in shaded areas. The pink bubblegum nudibranch, Hopkinsia rosacea, and the yellow dorids, Doriopsilla albopunctata and Anisodoris nobilis, were conspicuous in small pools beneath the surfgrass.

On the east side of the cove, large boulders with crevices and ledges create additional microhabitats. Therefore, species diversity was higher. The splash zone assemblage on the boulders was typical, including the California mussel, Mytilus californianus, the gooseneck barnacle, Pollicipes polymerus, and the limpet, Collisella digitalis. The ochre star, Pisaster ochraceous, was found on the sides of rocks.

Algal species in the mid to low zones included those found west of the cove along with Laurencia spp., other Iridaea spp., ocean pin cushion, Cladophora sp., Gigartina papillata, feather boa kelp, Egregia menziesii, and red fan, Cryptopleura lobulifera. Color changer, Desmarestia ligulata, albopunctata and Rostanga pulchra also were found. The sponge Ophlitaspongia pennata, and the tunicate Distaplia occidentalis, encrusted the sides and undersides of rocks.

From Lovers Point west to Lucas Point, the intertidal zone continues to consist of granite rock outcroppings interspersed with small sandy coves. Just west of Lucas Point, the intertidal area at the foot of Coral Street consists of granite boulders of varying sizes with fairly deep channels running between them. Sand was medium grained, indicating the relatively high degree of exposure. Although the intertidal habitat was more extensive than at other sites, there were no rock ledges which would favor aggregations of sponges, tunicates and hydroids.

The high intertidal zone was characterized by the common algae: small yellow rockweed, yellow rockweed, Pelvetia fastigiata, nail brush, and Gigartina papillata. Species of periwinkles, Littorina, and barnacles, Balanus, the gooseneck barnacle, Pollicipes polymerus, and the limpet Collisella digitalis were common invertebrates on rocks in this zone. The aggregating anemone occurred frequently at the base of the rocks.

Algal diversity increased lower in the intertidal. In addition to the above species, corallines, sea lettuce, and three species of turkish towel, Gigartina (G. leptorhynchos, G. canaliculata and G. spinosa) were common. Patches of Chaetomorpha sp. and the rockweed, Fucus distichus, occurred frequently, as did iridescent seaweed, red point, crinkled sea rose, and Leathesia nana.

Several algal species first appeared in the mid intertidal, in particular sea grapes, feather boa, Neoagardhiella baileyi, surfgrass, Phyllospadix scouleri and additional species of Iridaea. Corallines were common beneath other algae.

The low intertidal zone contained giant kelp, Macrocystis pyrifera, stipes, Cystoseira osmundacea, split whip, Laminaria farlowii, red fan, Cryptopleura lobulifera, and Gelidium sp. Sea palms were common seaward of large rocks directly in line with the surf. Reproducing surfgrass was also common in this zone.

Although invertebrate diversity was moderate, the thick algal cover obscured much of the fauna. Nudibranchs were conspicuous, due to their bright colors. Doriopsilla albopunctata, Rostanga pulchra, Hermassinda crassicornis, and Hopkinsia rosacea were the most common species; Anisodoris montereyensis, Diaulula sandiegensis, Aegires albopunctatus, Discodoris heathi and Cadlina flavomaculata were also found here. Other molluscs included the brown turban snail and the prosobranch Calliostoma canaliculatum. Commonly observed sea stars included the ochre sea star, the bat star, and the small six-rayed starfish, Leptasterias hexactis. The kelp crab, Pugettia producta, the porcelain crab, Petrolisthes cinctipes, and the furry Hapalogaster cavicauda were frequently noted crab species. Encrusting tunicates and sponges were seen occasionally, with the brown-colored Eudistoma psammion and the white E. molle the most common species of tunicates, and the red Plocamia karykina and Antho lithophoenix, white Leucosolenia eleanor and sharp-spined Stelletta clarella the most common species of sponges.

From Coral Street west to Asilomar Avenue, the intertidal area continues as large rocks and medium grained sand. At Asilomar Avenue, the western boundary of the ASBS, a rocky point extends out directly from the beach. The intertidal area was surveyed west of this point, in a rocky cove covered by small boulders with numerous small sandy pools. This was the most exposed rocky intertidal survey site, and consequently the species diversity was highest, even though the survey was conducted on only a medium low tide.

The splash zone, or Zone 1 (Ricketts and Calvin), on cliff sides harbored California mussel, Mytilus californianus, and various barnacles, Balanus sp.; the rocky shore crab, Pachygrapsus crassipes, was common in weathered rock crevices. Within the cove, the high intertidal zone was marked by a sparse algal cover of nail brush and shore brush, Rhodomela sp. Small pools contained coralline algae, abundant black turban snails, and small hermit crabs, Pagurus granosimanus and P. samuelis. Collisella limatula and C. pelta were common limpets in this zone.

Zone 2 (Ricketts and Calvin, 1968) showed an increase in algal cover; sea grapes, Iridaea flaccida, red point and Chaetomorpha linum made their first appearance in this zone. Patches of surf grass were found in sandy areas.

Invertebrates were also common in Zone 2. In addition to those observed in the high intertidal, the solitary anemone, serpulid worms, Spirorbis sp., and a keyhole limpet, Diodora aspera were common. The red sponge, Plocamissa igzo, was found under ledges with the small red anemone, Corynactis californica. The pink bubblegum nudibranch, Hopkinsia rosacea, was also observed in this zone.

In Zone 3, the lowest accessible zone, common algae included the iridescent Iridaea lineare, split whip, feather boa, Gigartina exasperata, and sea lettuce. Dictyoneurum californicum, Hymenena flabelligera, and corallines were also seen frequently. Sea palms could be seen, partially exposed, in Zone 4.

Molluscs were conspicuously abundant, particularly brown turban snails, serpulid worms, the snail Calliostoma annulatum, the carnivorous snail, Ceratosoma foliatum, the slipper shells, Crepidula sp., and the chitons Tonicella lineata and Mopalia muscosa. Small black abalone, Haliotis cracherodii, were found in crevices. Nudibranch species here included Hopkinsia rosacea, Laila cockerelli, Hermassinda crassicornis, Rostanga pulchra, and Phidiana pugnax.

Various crustaceans, cnidarians and echinoderms were also common here. The kelp crab, Pugettia producta, was frequently observed, as were the anemones Corynactis californica, Anthopleura xanthogrammica and Epiactis prolifera. Turbellarids and sertularian hydroids were found under ledges and rocks. The most common sea stars were the bat star and the ochre sea star.

Encrusting forms, particularly of tunicates, sponges, and bryozoans, were abundant in Zone 3. The tunicates Archidistoma psammion, A. molle, Aplidium californicum, Euherdmania claviformis, Metandrocarpa taylori and Clavelina huntsmani were abundant. Common sponges were Ophlitaspongia pennata, Acarnus erithacus, Toxadocea sp., Leucilla nuttingi, and Stelletta clarella. Several species of bryozoans were common, but could not be identified; Eurystomella bilabiata was observed frequently.

Although storm conditions and the early hours of low tides limited the detail of this intertidal survey, the species observed agree favorably with those listed by Stevenson and Stevenson (1972).

Landside Vegetation

Most of the bluffs adjacent to the ASBS have been landscaped, and few species of native vegetation remain. Both native species and exotic "weeds" persist in areas where landscaping has not been possible, or maintenance has been neglected.

Throughout Pacific Grove's history, a strict regulation on removal of trees has been pursued. As a result, the coastal parks contain numerous mature, carefully maintained trees which give the urban landscape a more natural appearance. The native Monterey Cypress, Cupressus macrocarpa, is the most common of these and is found in a variety of forms adjacent to the ASBS.

Few native shrubs are found adjacent to the ASBS. Toyon, Heteromeles sp., and manzanita, Arctostaphylos, occur in Jacobsen Park. Cliffside vegetation at the foot of Sea Palm Street is largely overgrown with wild rose, Rosa sp., and lupine, Lupinus sp. A few native species are used in landscaped areas. The city has used various species of the Carmel creeper, Pihosporum, and Australian tea tree as screens or barriers in the vicinity of the ASBS.

Most native species here are wild flowers or more perennial small plants. These occur most frequently at the interface between landscaped cliffs and the intertidal zone, and often in storm drain discharge areas. A partial list of native species, provided by the Pacific Grove Museum of Natural History, includes: buckwheat, Eriogonum parvifolium, wild radish, Raphanus sativus, cream cups, Platystemon californicus, clover, Trifolium fucatum, California poppy, Eschscholzia californica, mule's ears, Wyetha angustifolia, and lizard's tail, Eriophyllum staechadifolium.

Kikuyus grass, a species indigenous to Africa, is common just above granite outcroppings and elsewhere in the shoreline parks.

Unique Components

Sea otters, Enhydra lutris, have an important influence on the subtidal community in the ASBS and have been considered a keystone species (Pearse, 1974). The California population of otters, once thought extinct, expanded their range around Pt. Pinos and into the ASBS during the fall of 1962 (Faro, 1969). Faro observed up to 54 otters in his Point Pinos study area in 1967. In 1969, Odemar and Wilson reported a population density of at least 30 otters per square mile in the northern extreme of their range including Point Cabrillo, and estimated this to be above optimal supportable population density. He suggests these high densities in the Monterey area result from the barrier presented by the extensive sand areas between Monterey and Santa Cruz.

A large group of male otters (about 140), which has since moved northward, resided in the Point Cabrillo kelp bed from 1971 to 1976. Female otters now predominate in the ASBS. (Vandevere, pers. comm.)

Sea otters have aroused considerable scientific interest as they expand their range, dramatically affecting the subtidal community and shellfish resources. For instance, Faro (1969) reports that the Pt. Pinos area was once known to local skindivers as "the meatlocker", reflecting the abundance and accessibility of abalone. Although populations of abalone still exist in the ASBS, individuals are small (sub-legal) and restricted to crevices (Lowry and Pearse, 1973) probably as a result of sea otter predation. Though abalone is a preferred food item, the otter is an opportunist, feeding also on common large invertebrates such as urchins, mussels, rock crabs and squid (Wild and Ames, 1974, Vandevere, 1971).

Though the sea otter population is expanding, they may be particularly susceptible to an environmental catastrophe such as an oil spill. Vandevere suggests that since the entire California population is derived from an initial small group, reduced genetic variability may lessen their ability to respond to environmental changes. Martin (1974) has found high levels of cadmium in the otters (up to 964 ug/g dry kidney). The impact of the high levels of this toxic element on the otter is unknown. For an additional listing of marine mammals and sea birds observed in or near the ASBS, see Appendix 5.

LAND AND WATER USE DESCRIPTION

Marine Resource Harvesting

Commercial Fishing: Commercial fishing within the ASBS is largely limited to a few small boats that work on the outside fringe of the kelp beds or in sandy areas. Most boats prefer to fish in deeper water, where the larger fish are found and kelp beds do not limit the type of gear that can be used. Gear regulations further restrict the type of commercial fishing within the ASBS. The commercial take of invertebrates between the low tide mark out to 1000 feet (305 m) is prohibited. In addition, surfperch may not be taken during their May 1 and July 15 spawning season, and artificial lights may not be used to attract squid.

The squid fishery is by far the most important fishery within the ASBS. Historically, the squid fishery was limited to Monterey Bay. Although the fishery has expanded to Southern California in recent years, half the state's landings are from Monterey Bay. About 10 percent of the Monterey Bay landings are taken from within the ASBS. Over the twenty year period (1952-1971), this amounted to an average of 960,000 pounds/year.

The present fishery involves about 18 boats in the 30 to 50 foot size range, and about 120 fishermen. At the current wholesale price of 10 cents per pound, the average value of the resource within the ASBS to the fishermen is $96,000.00.

Surfperch landings within the ASBS amount to about 30 percent of Monterey Bay's Landing. Greatest landings occur in March and April and may be related to the pre-spawning nearshore movement of the perch and their increased availability to the skiff fisherman.

Jack mackerel are harvested within the ASBS by the same group of small boats that fish for surfperch. The percentage of the Monterey Bay area landings which is taken from within the ASBS varies with the size and number of boats participating in the fishery. During 1974 to 1976, the estimated catch within the ASBS was 9,500 pounds. At a market value

Life Refuge and the term "fish refuge" is easily interpreted to mean no fishing); (3) incompatibility of spear fishing with training and observation, major diver uses of the ASBS; and (4) low catch-per-unit effort (.82 fish per hour) in the ASBS as compared to nearby areas.

Free diving for abalone in the early 1960's had been a major sport fishing activity in Monterey County, including the ASBS. Between 1960 and 1972, the abalone catch by divers declined 99%, and only 25 abalone were taken by free divers in 1972. The 1972 CDFG report attributes the decline to the establishment of a sea otter population which preys heavily on abalone and other invertebrates. As the availability of the resource declined, so did fishing effort by free divers.

Kelp Harvesting: Although the ASBS contains extensive beds of giant kelp, *Macrocystis*, during the summer, there is no commercial kelp harvesting.

Municipal and Industrial Activities

Municipal: The ASBS is adjacent to the town of Pacific Grove, population 17,000. The boundary of the ASBS is a seaward extension of the eastern boundary of the city, marked by Eardley Avenue. The western boundary of the ASBS is a seaward extension of Asilomar Avenue.

Industrial: Pacific Grove industry consists of about sixteen motels, a half-dozen laundromats and commercial laundries, and twenty-five restaurants. The motels contribute primarily domestic wastewater to the sewer system. Several of the town's largest restaurants and motels are located at Lovers Point.

Hopkins Marine Station, affiliated with Stanford University, occupies 8.2 acres (3.3 hectares) of land at Cabrillo Point and is a well known landmark. Three laboratory buildings form the prominent physical features of the station. The presence of Hopkins Marine Station at Cabrillo Point attests to the biological significance of the nearshore waters.

The ASBS is also used by a surprisingly high number of surfers, considering the less than ideal surfing conditions.

Swimming in the ASBS is restricted to the few months when the water temperature is high enough to permit swimming without a wet suit, and even then is of short duration. Most swimming occurs at Lovers Point Cove, which is somewhat protected from wave action. Sunbathing is a more common activity, particularly at Lovers Point Cove.

Scientific Use

Hopkins Marine Life Refuge: Scientific use of this reserve served as the main reason for designating it an ASBS. Historically, Hopkins has been the primary academic institution to use the refuge for scientific research. As early as 1920, the station was open all year round, and had a running seawater system. Then, as now, researchers used the refuge primarily as collecting grounds for small numbers of common invertebrates.

Hopkins began making daily shore temperature and salinity readings in 1919. Interest in oceanographic features of the refuge increased in the 1930's, with Skogsberg's hydrobiological survey of Monterey Bay. A sampling station was established just seaward of the reserve and retained thereafter in the regular CALCOFI sampling program.

Marine algae became a more common research topic at Hopkins in the 1930's, and in 1940, Gilbert M. Smith published his "Provisional key to genera of marine algae of the Monterey Peninsula."

Between 1950 and 1975, research at Hopkins resulted in the publication of over 600 scientific articles and papers.

The reserve is used almost exclusively for ecological (usually, intertidal) studies which require undisturbed conditions. Collecting is restricted to species whose numbers are readily replenished by reproduction or by the next tide. These include some species of ascidians, kelp flies, and *Tygriopus californicus*. Collecting is generally done west of Cabrillo Point, away from the study sites to the east.

The subtidal portion of Hopkins Marine Life Refuge has been described by Dr. D. P. Abbott as "...the only natural and relatively undisturbed reef in the entire Monterey area." For this reason, both the University of California at Santa Cruz and the California Department of Fish and Game have used the area to obtain baseline information on kelp beds and kelp bed ecology.

Pacific Grove Marine Gardens Fish Refuge: Compared with Hopkins Marine Life Refuge, very little scientific research has been conducted in this refuge. Basically, this is because Hopkins is a more attractive alternative which is equally accessible to the area's academic and governmental institutions. The intertidal zone in the fish refuge is less protected from wave action and human disturbance. Diver and pedestrian access is limited, and diving conditions are highly variable and more dangerous than at Hopkins. And, finally, the refuge is further away from the supportive facilities at Hopkins Marine Station.

The Department of Fish and Game did a study in 1977 using the reef off Lovers Point to study (1) the effect of kelp harvesting on fish, particularly juveniles, and (2) the relative accuracy of measuring population size by visual transects, and by the mark and recapture method.

Since 1960, the Department has conducted in the ASBS life history studies of important sport fishes in central California.

Transportation Corridors

The close proximity of Pacific Grove and the ASBS is responsible for a network of surface city streets carrying traffic near the ASBS. Heavy use of these corridors is experienced during weekends and summer periods, especially.

Maritime traffic moves through and just offshore of the ASBS in large quantities. Vessels near the ASBS are primarily recreational craft or commercial fishing boats. Major shipping lanes lie substantially offshore.

ACTUAL OR POTENTIAL POLLUTION THREATS

Point Sources

Municipal and Industrial Wastes: Pacific Grove's waste water collection system conveys wastes by gravity flow to the treatment plant. The present collection system constitutes a source of water pollution primarily when pump station failures occur and it is necessary to divert incoming sewage to the ASBS. Three failures were recorded between 1967 and 1977. The quantity of sewage diverted at this point is almost the entire influent flow of the plant.

Storm conditions can also result in utilization of a cross-connection between a sewer line and storm drain. During heavy rains, sewage flows can be sufficiently high to cause overflow into the storm drain. The cross-connection is also a bypass point in the event of a pumping plant failure.

The sewage treatment plant serving the City of Pacific Grove discharges an average of 1.4 MGD of primary treated effluent to the low intertidal zone just west of Pt. Pinos, about .4 miles west of the ASBS (Figure 4). This plant is scheduled to be abandoned in mid-1980, as part of the regionalization of the Monterey Peninsula's sewage treatment system.

During the past ten years, the Pacific Grove plant has been forced to bypass four times. The longest period of bypassing, five days, occurred in 1969 and in 1973. Occasionally, operational difficulties do not result in bypassing, but in inadequate disinfection of the effluent. The chlorinator has ceased to function four times in the last ten years, most often during storms. Thus, disinfection is lacking when the discharge level is at a maximum.

Effluent strength is typical for domestic wastewater receiving primary treatment. Average 1975-1976 values for parameters tested were:

Constituent	Average Effluent Value 1975-1976
Chlorine Residual	1.3 ppm
Settleable Solids	.23 mg/1
Total Suspended Solids	59 mg/1
pH	7.5
Phosphates	25 mg/1
Nitrogen	36 mg/1

The primary treated effluent is discharged just west of Pt. Pinos (.4 miles or .6 km west of the ASBS), about 600 feet offshore. The receiving waters are monitored for total coliform. As Table 7 shows, offshore station values are generally highest during the Oceanic Period; highest values at beach stations 4 and 6 occur when the Davidson Current dominates. Highest values for station 5, closest to the outfall, occur between June and November.

Between 1975-1977 average total coliform counts at station 5 exceeded public health standards of MPN 1000/100 ml for water contact sports. Average monthly values at beach station 6 also exceeded public health standards during October, November, and December of 1975. However, the highest value recorded at beach station 4, about 500 ft. (153 m) west of the ASBS, was 278/100 ml, well within public health standards. Pt. Pinos provides a significant barrier to the eastward dispersion of wastewater as demonstrated by studies from Hopkins Marine Station (Tables 8 and 9).

Pt. Pinos also creates localized current patterns which tend to direct wastewater offshore. Blaskovich (1973) found that drift cards dropped at Pt. Pinos were recovered at Moss Beach (to the south), offshore, or east near Fort Ord. Recoveries were rarely made within the ASBS, usually when northerly winds were strong and offshore currents too weak to counteract their influence. In a 1969 study by Engineering-Science, Inc. (ESI), 93 percent of the drift cards released 500 to 1000 yards (458 to 915 m) offshore from Pt. Pinos were recovered west of the outfall.

RECEIVING WATER DATA

PT. PINOS OUTFALL

TABLE 7 . AVERAGE VALUES FOR TOTAL COLIFORM (JULY 1975-JUNE 1977)

Beach Stations (sampled from shore)	MPN/100 ml	Offshore Stations (sampled from boat)	MPN/100 ml
4 (~1000' East of outfall)	75	1 (~1000' offshore &) (in line w/sta. #4)	66
5 (Just shoreward of outfall)	2905	2 (~1000' offshore) (from outfall)	176
6 (~1000' West of outfall)	683	3 (~1000' offshore &) (in line w/sta. #6)	211

PT. PINOS OUTFALL
TABLE 8 . RECEIVING WATER DATA; MAY 22, 1970

Constituent	LOW TIDE			HIGH TIDE		
	Sewage Field[2]	Outfall Station	Background Station[3]	Sewage Field	Outfall Station[4]	Background Station
Salinity	18.65 ppt(5)	.98ppt	33.97	31.18(4)	31.04	33.66
°C Temperature	18.1(3)	19.2	12.4	No Significant Difference		
pH	7.12(5)	6.61	8.03	7.8(5)	7.8	8.2
Phosphate (ug-a/1)	60.8(5)	76	1.0	26.6(5)	2.0	0.9
Chlorine	5.6 mg/1(5)	11	0	0	0	0
Dissolved Oxygen	2.6 mg/1(6)	2.0	(7.2)[3]	6.9(3)	7.0	8.1

1. From Hopkins Marine Station undergraduate paper, by David Clearman.

2. Those stations where values differ significantly from background level. All within 10 yards of outfall. Number in parenthesis is number of stations in sewage field.

3. Taken at Hopkins Marine Station. No data from Hopkins for DO, so value here is highest measured at Pt. Pinos.

4. Outfall station not accessible on high tide. Values from station next closest to outfall.

The Pacific Grove discharge probably has a significant adverse impact on the intertidal and shallow subtidal biota in its immediate vicinity, and affects water quality adversely west of the outfall. However, the scant data available do not indicate that water quality in the ASBS is adversely affected by the discharge.

Hopkins Marine Station Seawater System: Both the intake and four discharge lines from the Hopkins seawater system are located within the ASBS (Figure 4).

Many of the components of the seawater system were built as early as 1929, and the system has facilitated research work at Hopkins for several decades. However, the discharge has been monitored only briefly (a year and a half) and for few parameters. Average values for that period of time were:

Constituent	Influent	Agassiz Discharge	Marinostat
Temperature (°F)	56.1	55.3	55.4
Turbidity	25 JTU	25 JTU	25 JTU
pH	-	7.9	7.7
Total Suspended Solids (TSS)	-	1.66	1.62
Settleable Solids (SS)		.002 mg/1	.002 mg/1

Total daily flow from the discharges is difficult to estimate at the present time, as the system is being altered somewhat. The previous discharge permit allowed a maximum combined discharge of 93,000 gpd from Agassiz Beach and Cabrillo Point (equivalent to about 30 gpm for each discharge). The Agassiz Beach discharges are largely absorbed by the coarse grain sand beach before they reach the water. The other two discharges are to areas above the intertidal zone; the only observable effect is the creation of a small artificial "splash" zone on the granite rocks, with appropriate algae and invertebrate populations.

of water pollution to the ASBS. All industrial activities discharge to the community sewer. Regulations specifically exclude activities which could generate water pollution: fish cleaning, bilge pumping, major repairs, living on board more than 48 hours, and "pollution or littering in any form."

Monterey Harbor is protected on the west side by a granite rock breakwater and 400 foot extension. The United States Coast Guard moors two cutters and two utility boats here; two Army patrol boats are also moored here. The Coast Guard boats are painted and repaired at this location. This activity may generate a small amount of water pollution in nearby waters, but would not affect water quality in the ASBS.

-1966. CALCOFI Investigative Report 11:155-156.

Brief summary of trends and fluctuations.

III. Oceanographic Work by Moss Landing Marine Laboratories.

1. Blaskovich, David D. 1973. A Drift Card Study in Monterey Bay, California: September 1971 to April 1973. Moss Landing Marine Laboratories, Moss Landing, California. Tech. Pub. 73-74.

Study of short term movement of surface waters in Monterey Bay using drift cards. Location, time, and percentage recovery correlated with wind speed and oceanographic season. Theoretical trajectories of cards plotted for each month. Influence of tides and diurnal winds measured with drift cards released during one 24-hour period.

2. Moss Landing Marine Laboratories. CALCOFI Hydrographic Data Report, Monterey Bay. (Published as separate volumes for 1974, 1975 and 1976).

Contains raw data obtained by Moss Landing at five of the original CALCOFI stations. Data collected at various times of day; biweekly through 1976 and monthly thereafter. Weather, time, date and location recorded at each station as sampled. For Station 1: data on transparency, temperature, salinity, DO, nutrients and ammonia for 0, 5, 10 and 20 meter depths.

3. Broenkow, William W. 1972. Oceanographic Observations in Monterey Bay, California, February 1971 - December 1971. Moss Landing Marine Laboratories, Moss Landing, California. Tech. Pub. 72-1. 205 pp.

Raw data from first phase of comprehensive oceanographic survey of Monterey Bay, funded by Sea Grant and the Association of Monterey Bay Area Governments (AMBAG); stations in south bay added in the fall; twenty-one stations sampled altogether. Stations closest to ASBS were (1) off Pt. Pinos, at 40 meter depth and (2) one mile east of ASBS, at about 18 meter depth. Samples collected at 5-10 meter depth intervals and analyzed for: temperature, salinity, density, dissolved oxygen, nutrients, ammonia and silicate.

4. Broenkow, William W. and Sandra R. Benz. 1973. Oceanographic Observations in Monterey Bay, California. January 1972 to April 1973, Moss Landing Marine Laboratories, Moss Landing, California. Tech. Pub. 73-3. 336 pp.

Raw data from second phase of AMBAG oceanographic survey conducted by Moss Landing. Stations occupied, depths sampled and analyses performed are as outlined for Broenkow (1972), except all twenty-one stations were sampled once a month.

5. Broenkow, William W. and William M. Smethe, Jr. (in press). Surface Circulation and Replacement of Water in Monterey Bay.

Analysis and discussion of Monterey Bay surface waters (0-10 meters) as characterized by AMBAG cruise data. Seasonal temperature and salinity fluctuations are related to possible causitive factors: oceanographic regime, freshwater runoff, direction and magnitude of local winds. Data on temperature and nutrients at different stations used to estimate residence time in the north and south bight. Observed ammonia concentrations compared with expected concentrations as calculated from sewage discharge strength and residence time.

6. Lasley, Stephen Rogers. 1977. Hydrographic Changes in Monterey Bay Surface Waters in Relation to Nearshore Circulation. M.S. Thesis, San Jose State University, San Jose, California. 75 pp.

Study attempted to quantify short-term changes occurring in distribution and concentration of oceanographic parameters. Field work done June-July 1977; most changes discussed accompanied the cessation of upwelling caused by local winds. Characteristics of area off Pt. Pinos compared with other stations in Monterey Bay.

IV. <u>Oceanographic Work Done by United States Naval Postgraduate School</u>.

1. Stevenson, Connelly D. 1964. A Study of Currents In Southern Monterey Bay. M.S. Thesis, United States Naval Postgraduate School, Monterey, California. 67 pp.

Drogues used to track current direction and speed in shallow water (< 60' depth) near the Monterey sewage treatment plant outfall. Drogues set at 2', 4', 8', and 14' depths. Position determined every 10 minutes; total tracking time ranged from 40 minutes to 5 hours and 40 minutes. Drogue trajectories correlated with wind direction and speed.

Explanation of geometry and computer program used to calculate drogue position and analyze data is included.

2. Lammers, Lennis Larry. 1971. A Study of Mean Monthly Thermal Conditions and Inferred Currents in Monterey Bay. M.S. Thesis, United States Naval Postgraduate School, Monterey, California. 164 pp.

Study presents mean monthly sea surface temperatures for Monterey Bay, based on data collected between 1929-68. Averages were compiled separately for 19 "blocks" of 4 mile x 4 mile size and then combined to obtain horizontal gradients for each month. Block 1 includes ASBS and extends to the 50 fathom contour. Seasonal temperature changes occurring over the canyon and in the shallows are compared. Variation in the depth of the predominant midwater isotherms used to infer mean monthly current direction and magnitude. Discussion of factors causing inferred currents; comparison of inferred currents with currents as directly measured in various studies. Computer program used to compile and store data is outlined.

3. Anderson, Raymond Charles. 1971. Thermal Conditions in Monterey Bay during September 1966 through September 1967 and January through June 1971. M.S. Thesis, United States Naval Postgraduate School (USNPGS), Monterey, California.

For these time periods, data from CALCOFI and USNPGS cruises is analyzed and discussed. Comparison of data from key stations is used to identify the onset of particular oceanographic seasons. Offshore transect data is correlated with oceanographic events occurring in the bay. Data compared with 40 year norm calculated by Lammers (1971). Anomalous thermal conditions graphed and discussed.

4. Garcia, Roland Albert. 1971. Numerical Simulation of Currents in Monterey Bay. M.S. Thesis, United States Naval Postgraduate School, Monterey, California. 154 pp.

Thesis develops mathematical models for predicting circulation patterns in (1) a simple embayment, and (2) Monterey Bay. The refined model for Monterey Bay considers bottom topography as a variable, as well as vorticity and streamflow. Bottom friction is considered negligible for the bay's typically deep waters. Both models have limited applicability to the ASBS, which is a shallow bottom area located in the southern corner of the bay (The shape of the bay was approximated for the models and the corners in particular were not drawn accurately).

5. McClelland, Joseph James, Jr. 1972. An Oceanographic Investigation of Thermal Changes in Monterey Bay, California September 1971 - January 1972. M.S. Thesis, United States Postgraduate School, Monterey, California.

Author's intention was to examine more closely phenomena associated with the Oceanic and Davidson oceanographic periods as they occur in Monterey Bay. General discussion of the manner and degree to which study period differed from the "typical" oceanographic regimes. Examination of geographical differences (within bay) in isotherm fluctuation, sea surface temperature and rates of change. Temperature-salinity curves graphed and discussed as indicators of different offshore currents entering the bay. Some measurement of offshore current direction and speed.

6. Moomy, David Howard. 1973. Temperature Variations Throughout Monterey Bay September 1971 - October 1972. M.S. Thesis, United States Naval Postgraduate School, Monterey, California 166 pp.

Author examined temperature and salinity data from weekly sampling of nine Monterey Bay stations; southern shallow stations were offshore ASBS, in water of 50 meter depth. Temporal and spatial temperature fluctuations compared with 40-year averages and upwelling index for offshore waters. Comparison of east-west, and north-south temperature variations during study period. Examination of 10° isotherm topography. Currents at 10 m depth compared with flow inferred from differences in surface temperature and density. Comparison of current direction offshore and within the bay; discussion of data on currents as it relates to Garcia's model of circulation within Monterey Bay.

7. Reise, Jeffrey Alan. 1973. A Drift Bottle Study of the Southern Monterey Bay. M.S. Thesis, United States Naval Postgraduate School, Monterey, California. 113 pp.

Drift bottles were used to study seasonal variations in surface currents near known sources of water pollution: Monterey Harbor, Monterey outfall, and Seaside outfall. Drop station closest to ASBS is about ½ mile offshore from Cannery Row. Recovery data is correlated with seasonal and diurnal wind direction, Garcia's Bay circulation models, and results from other current studies.

V. Summary Report

1. Scott, David A. 1973. AMBAG Oceanographic Survey, Draft Copy. Santa Barbara, California. Oceanographic Services, Inc. #168-2.

Report analyzes, integrates and interprets oceanographic data from AMBAG contract work and previous studies. The intent is "to provide an understanding of the extent to which Monterey Bay.... can be used as a receiving basin for wastewater." A water pollution sensitivity index for the bay is developed, based on (1) circulation patterns, (2) levels of certain water quality parameters, and (3) location of marine species of importance to sport and commercial fisheries. Raw data contained in appendices.

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Intertidal Description

1. Abbott, Donald P. 1947. The littoral ascidians of Monterey Bay and vicinity. Unpublished Student Report, U.C. Berkeley. Zoology 112-212, volume 16. 35 pp.

2. Abbott, Isabella A. 1972. Carmel Bay interim report (biological) for the Carmel Sanitary District. 73 pp. (see Receiving Water Monitoring Reports for annotation)

3. Abbott, Isabella A. and George J. Hollenberg. 1976. Marine Alage of California. Stanford University Press, Stanford, California. 827 pp.

Revision of the taxonomy of the algal species on the California coast, description and synonomies for each species, diagrams of most species and a key to the genera.

4. Bolin, Rolf L. 1934. Studies on California Cottidae: An analysis of the principles of systematic ichthyology. Ph. D. dissertation. Stanford University. 337 pp. (at Hopkins Marine Station).

Revision of the taxonomy of the cottids.

5. Bowman, Thomas E. 1947. The hydroids of the Monterey Bay region. Unpublished Student Report, U.C. Berkeley. Zoology 112-212, volume 16. 16 pp.

6. Brumbaugh, Joe H. 1964. The anatomy, diet and Tentacular mechanism of the dendrochirote holothurian Cucumaria curata Cowles 1907. Ph. D. dissertation, Stanford University. 119 pp. (at Hopkins Marine Station).

7. Davis, John. 1947. Notes on some isopods of the Monterey Peninsula intertidal. Unpublished Student Report, U.C. Berkeley. Zoology 112-212, volume 16. 22 pp.

8. De Laubenfels, M. W. 1932. The marine and freshwater sponges of California. Proc. U.S. Nat. Museum 81:1-140.

Initial and until recently the only major work on California sponges. Much of the material used for this study came from Monterey and Carmel Bay.

9. Engineering Science, Inc. 1977. Oceanographic Investigations in Carmel Bay-Review of Existing Information. 185 pp. (see Receiving Water Monitoring Reports for annotation).

10. Environmental Services Division. 1974. Carmel Bay Monitoring Program Final Report, February 1974. 140 pp. (see Receiving Water Monitoring Reports for annotation).

11. Fell, Paul Erven. 1967. The role of nurse cells in oogenesis and embryonic development in the marine sponge, Haliclona ecbasis. Ph. D. dissertation, Stanford University. (at Hopkins Marine Station).

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13. Frazier, Ralph R. 1947. A survey of the gastropoda of Mytilus californianus communities on Mussel Point, California. Unpublished Student Report, U.C. Berkeley. Zoology 112-212, volume 16. 20 pp.

14. Goff, Richard A. 1947. Macrofauna in Pelvetia beds. Unpublished Student Report, U.C. Berkeley. Zoology 112-212, volume 16. 10 pp.

15. Gordon, Leslie S. 1947. Some factors which influence the distribution of chitons in the Monterey area. Unpublished Student Report, U.C. Berkeley. Zoology 112-212, 32 pp.

16. Hand, Cadet. 1954. The sea anemones of central California. Part I: The Corallimorpharian and Athenarian anemones. Wasmann J. Biol. 12:3, 345-75.

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18. Hand, Cadet. 1955b. The sea anemones of central California. Part III: The Acontiarian anemones. Wasmann J. Biol. 13:2, 189-251.

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20. May, R. M. 1924. Ophiurans of Monterey Bay. Proc. Calif. Acad. Sci. (4) 13:261-303.

Original work on brittle stars in Monterey Bay.

21. McDonald, Gary R. 1977. A review of the nudibranchs of the California coast. Unpublished M.S. Thesis, California State University, Hayward. 373 pp.

22. McLean, James H. 1966. West American Prosobranch Gastropoda: Superfamilies Patellacea, Pleurotomariacea and Fissurellacea. Ph. D. Dissertation, Stanford University. 255 pp.

23. Ricketts, Edward F. and Jack Calvin. 1968. Between Pacific Tides. Fourth edition, revised by Joel W. Hedgpeth. Stanford University Press, Stanford, California. 614 pp.

Classic text describing intertidal flora and fauna of the Pacific coast, mostly northern California. Various habitats and characteristic organisms are described. Systematic index is included as well as an annotated bibliography.

24. Smith, Allyn G. and McKenzie, Gordon Jr. 1948. The Marine mollusks and branchiopods of Monterey Bay, California and vicinity. Proc. Calif. Acad. Sci. 4:26,8,147-245.

25. Smith, Gilbert M. 1944. Marine Algae of the Monterey Peninsula, California. Stanford University Press, Stanford, California. 622 pp.

26. Smith, Ralph I. and James T. Carlton, eds. 1975. Lights Manual: Intertidal Invertebrates of the Central California Coast. Third edition. U.C. Press; Berkeley, California. 716 pp.

Contains keys for intertidal invertebrates of the central California coast; figures and brief synonomies included.

27. Stephenson, T. A. and Anne Stephenson. 1972. Life between tidemarks on rocky shores. W. H. Freeman and Co., San Francisco, CA. 425 pp.

Discusses rocky intertidal areas throughout the world. Section on Pacific Grove includes data from Carmel Bay.

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Subtidal Description

1. Abbott, I. A. 1973. Carmel Bay interim report. (Biological). Prepared for the Carmel Sanitary District, Carmel, California.

2. Aleem, A. A. 1973. Ecology of a kelp bed in southern California. Botanica Marina 17(2):83-95.

3. Alevizon, W. S. 1975. Spatial Overlap and competion in congeneric surfperches (Embiotocidae) off Santa Barbara, California. Copeia 352-356.

4. Andrews, H. L. 1945. The kelp beds of the Monterey region. Ecology 26(1):24-37.

Compares fauna of kelp holdfasts at six sites on the Monterey Peninsula, including Point Cabrillo, Lovers Point, and Point Pinos within the ASBS. Brief descriptive notes on the subtidal.

5. Barrales, H. L. and C. S. Loban. 1975. The comparative ecology of *Macrocystis pyrifera* with emphasis on the forests of Chubut, Argentina. J. Ecol. 63:657-677.

6. Bolin, R. L. and D. P. Abbott. 1963. Studies on marine climate and phytoplankton of the coast of California 1954-1960.

Monthly phytoplankton samples were taken; settled volumes were estimated and plankters indentified to genus. The peak phytoplankton volume tended to occur in June, associated with high light and nutrient levels. Maximum taxonomic complexity was seen at the beginning of each marine season; as the season developed certain forms tended to become dominant. *Chaetoceros* peaked in the Upwelling Season, *Rhizosolenia* during the Davidson current period.

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8. DeMartini, J. D., S. Jones and C. Seltenrich. 1977. A macrobiological survey of Trinidad Bay, California. Humbolt State University Marine Laboratory. Trinidad, California. Unpublished report for the North Coast Coastal Commission.

9. Devinny, J. S. and P. D. Kirkwood. 1974. Algae associated with kelp beds of the Monterey Peninsula, California. Botanica Marina 17:100-106.

One-time survey of subtidal algae at five kelp bed sites, including Point Cabrillo and Lucas Point within the ASBS. Discusses distribution of the algae with respect to depth and exposure.

10. Faro, J. B. 1969. A survey of the subtidal sea otter habitat off Point Pinos. M.S. Thesis, California State University, Humbolt. 278 pp.

A lengthy description of the abundance and distribution of the subtidal macrobiota at Pt. Pinos with emphasis on sea otter food organisms.

11. Fitch, J. E. and R. J. Lavenberg. 1971. Marine food and game fishes of California. University of California Press, Berkely, California. 179 pp.

12. Garrison, D. L. 1971. Plankton productivity and particulate material: pp. 92-94. In J. S. Pearse (ed.) kelp bed as a classroom. Results of a 5-week class study of kelp beds in the Monterey Bay region. Hopkins Marine Station Class Report 270. Pacific Grove, California. 139 pp.

Examines nature of particulate material and determines relative plankton productivity. Estimates plankton contributes only 20% of particulate organic carbon and discusses probable importance of macroalgae as a source.

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14. Gerard, V. A. 1976. Some aspects of material dynamics and energy flow in a kelp forest in Monterey Bay, California. Ph. D. Thesis, Stanford University, California. 173 pp.

Measured standing crop, production and loss of *Macrocystis pyrifera* during a 2.5 year study at Point Cabrillo. Species composition, standing crop, export and decomposition of benthic drift plants and their utilization by the bat star *Patiria miniata* were also examined. This study obtained important basic information about the seasonal and long term dynamics of *M. pyrifera* at Pt. Cabrillo and its importance in the energetics of the kelp forest community here.

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16. Houk, J. 1977. Central California marine sportfish survey: Distribution and relative abundances of juvenile sportfish. Job Performance Report, Project No. D-J. F-25-R-10, California Dept. of Fish and Game, Monterey, California.

Progress report on an ongoing study which involves mark and recapture and underwater fish transects to estimate juvenile sportfish distribution and abundance. Study also involved experimental kelp cutting, to determine effects on fish populations. One primary study site is at Lovers Point.

26. Pearse, J. S. (ed.) 1971. Kelp bed as a classroom. Hopkins Mar. Sta. Class Repts 270H. Pacific Grove, California. 139 pp.

Intensive five week study focused primarily on the kelp beds at Pt. Cabrillo. Resulting annotated species lists were updated and revised by Pearse and Lowry (1974). Special problems studied included water column characteristics, productivity and feeding, and growth rates and physiology of selected organisms. Species densities at Pt. Cabrillo are compared with five other kelp bed sites.

27. Pearse, J. S. and A. H. Hines. 1976. Kelp forest ecology of the central California coast. Sea Grant R/A-16c Annual Report. 5 pp.

Report describes studies in progress including seasonal distribution, abundance and feeding rates of important kelp bed organisms. Objective is to quantify ecological interactions in the kelp forest at Point Cabrillo.

28. Pearse, J. S. and L. F. Lowry. (ed.) 1974. An annotated species list of the benthic algae and invertebrates in the kelp forest community at Point Cabrillo, Pacific Grove, California. University California Santa Cruz Mar. Lab. Tech. Rept. No. 1. 73 pp.

Pearse includes a brief description of the subtidal off Pt. Cabrillo and lists 369 species of algae and invertebrates known to occur there. Very useful reference for the ASBS.

29. Pearse, J. S. and A. Weaver. 1971. Diving reconnaissance in Coliform Cove, Point Pinos, Pacific Grove. 4 August 1971. Unpublished M 2 pp.

Dive notes near site of the Pacific Grove outfall.

30. Quast, J. C. 1968. Observations on the food of the kelp bed fishes. In W. J. North and C. L. Hubbs (eds.) The utilization of kelp bed resources in Southern California. California Fish and Game, Fish Bulletin 139. 264 pp.

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Study site at Point Cabrillo.

35. Vandevere, J. E. 1971. Fecal analysis of the southern sea otter. Proc. Eighth Ann. Conf. Biol. Sonar and Div. Mamm. Stanford Res. Inst., Menlo Park, CA. pp. 97-103.

Analyzed 200 fecal samples collected from one otter which hauled out regularly at Point Cabrillo.

36. Wild, P. W. and J. A. Ames. 1974. A report on the sea otter, *Enhydra lutris L.* in California. Cal. Dept. Fish and Game Mar. Res. Tech. Rept. No. 20. 94 pp.

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Land/Water Use, Sources of Water Pollution

I. History

1. Federal Writer's Project. 1941. Monterey Peninsula. Stanford University, California. Ed. by J. L. Delkin. 207 pp.

Includes a somewhat critical summary of Pacific Grove's early history, and a description of the town as it was in 1940. Lists points of interest and gives a brief history of each.

2. Howard, Donald M. 1975. Primitives in Paradise: An Archaeological History of the Monterey Peninsula. Carmel, California. 71 pp.

Lists location, contents and condition of local archaeological sites, several of which border ASBS. Photographs and brief description of use of shell artifacts by local Indians.

3. McLane, Lucy Neely. 1952. A Piney Paradise by Monterey Bay. San Francisco, California. 231 pp.

Annecdotal and detailed history of Pacific Grove's first 25 years (1875-1900), during which time local institutions and public services were established. Much information from local newspapers and old-time residents. Recently made available in paperback.

4. Stanford University, Hopkins Marine Station. 1900-1930 (Reprints). Pamphlets.

Reprints of articles originally published in various periodicals in 1900, 1907, 1918, 1920, 1929 and 1930. Articles outline early history of Hopkins Marine Station, and describe current research, facilities available, and local flora and fauna.

5. Writer's Group of Canterbury Woods Retirement Home. 1968. Pacific Grove, California: This is our Town. Monterey, California. 64 pp.

Articles on Pacific Grove's early history, buildings, distinguished citizens, and natural history.

II. Commercial Fishing Activity

1. California Department of Fish and Game. 1970-1974. Report 1-AA. Catch by Origin by Species. Data utilized from Catch Block 526.

2. Local source of information: Jim Hardwick, biologist, Department of Fish and Game.

Estimates of percentage of Catch Block 526 taken within ASBS, by fishery. Size and type of commercial fisheries within ASBS.

III. Sportfishing Activity

1. Miller, Daniel J., et. al. 1967. Life History and Catch Analysis of the Blue Rockfish (Sebastodes mystinus) off Central California, 1961-1965. California Department of Fish and Game, Marine Resources Operations Reference 67-14, 130 pp.

Length frequency data on blue rockfish for partyboat, skiff and spear fisheries; related to age. Catch composition of skiff sport catches, different reefs in or adjacent to the ASBS.

2. Miller, Daniel J., et. al. 1974. Results of the 1972 Skin diving Assessment Survey, Pismo Beach to Oregon. California Department of Fish and Game Marine Resources Technical Report No. 23 (manuscript). 61 pp.

Catch composition of fish and invertebrates taken by divers by county. Total diver catch and catch-per-unit effort by sampling port. Comparison with 1960 figures, and discussion of impact of sea otter on diver catches of abalone.

IV. Municipal and Industrial Activities

1. City of Pacific Grove. 1972. The General Plan of the City of Pacific Grove. Pacific Grove, California. 81 pp.

Part III gives the market value (then), condition and density of Pacific Grove housing. Identifies ways and means of improving housing and its availability. Recommends areas where housing should be conserved and/or rehabilitated.

2. City of Pacific Grove. 1977. Zoning Ordinance. Pacific Grove, California. 50 pp.

Regulations for each zoning district include: uses permitted and excluded, maximum allowable building height and coverage and minimum allowable lot and yard size.

3. Monterey County Planning Department. 1973. Monterey County Facts and Figures. Monterey, California. 8 pp.

For Pacific Grove, vital statistics on population, population density, land area, assessed valuation, type of housing (owner/renter), economic status of population.

4. Monterey Peninsula Chamber of Commerce, and Council of Monterey Bay, Inc. 1974. 1973 Statistical Review. Monterey, California. 18 pp.

Fact sheet on Pacific Grove, population trends, taxable sales, building permit information for 1971-1973.

5. Salinas Chamber of Commerce. 1975. Industry Directory for Salinas and Monterey County, California. Salinas, California. 63 pp.

Describes district's regulations and source control activities. Air emission levels are summarized by contaminant, source, station and season. Major point sources identified; comparisons with previous years.

4. Local sources of information:

   (a) Robert Feeney, City Engineer, Pacific Grove.

   (b) Gary Tate, Monterey Regional Park District. Development of Southern Pacific right-of-way into bikeway/hiking trail.

IX. <u>Actual or Potential Water Pollution Threats: Point Sources</u>

1. City of Monterey, Department of Public Works. 1976. <u>Report on Operation, Water Pollution Control Plant</u>, City of Monterey. Monterey, California. 47 pp., appendices.

Preface describes secondary treatment plant following its completion in 1970.

Contains annual reports and plant records for July 1971-July 1975 (4 fiscal years). Annual reports describe operational problems and correlate them with design limitations of plant, and above average effluent strength. Conclusion lists recommendations for additional equipment, maintenance work and design changes. Appendices contain average monthly and annual values for wastewater parameters which indicate strength of plant influent and effluent.

2. City of Pacific Grove, Planning Department. 1972. <u>The General Plan of the City of Pacific Grove</u>. Pacific Grove, California. 81 pp.

Part II describes the age and condition of the city's sewage collection system, and storm drains.

3. Engineering-Science, Inc. 1967. <u>Sewerage Facilities for Pacific Grove, California</u>. Oakland, California. 53 pp. appendices.

Describes City of Pacific Grove treatment plant, outfall, and collection system in detail.

Describes wastewater characteristics of treatment plant effluent. Recommends corrective measures to be taken at treatment plant and within collection system to improve quality of discharge. Recommends outfall extension and considers feasibility of reclaiming wastewater and using it to irrigate adjacent golf course and parks.

4. Engineering-Science, Inc. 1970. <u>Point Pinos outfall feasibility Study</u>. Berkeley, California.

Study characterized nearshore waters in the vicinity of Pt. Pinos to determine optimal length and orientation of outfall extension and diffuser structure. Measurements of currents, salinity, temperature, floatables, nutrients, zooplankton and coliform at three depths; eight sampling stations located from Moss Beach to Lucas Point. Some measurement of influent and effluent wastwater characteristics. Sampling plant, Monterey Regional County Sanitation District. Pacific Grove treatment plant, operating problems, plant records.

(b) Al Hart, Superintendent, Monterey Regional County Sanitation District. Monterey Treatment Plant.

(c) Mr. John Kono, Mr. Dick Haff, Dr. Don Abbott, Mr. Richard Blanton of Hopkins Marine Station. Seawater system at Hopkins Marine Station.

(d) Mr. Jay Nighswonger, California Regional Water Quality Control Board #2. Monitoring data, Hopkins Marine Station seawater system.

X. Actual or Potential Water Pollution Threats: Non-Point Sources

Local sources of information:

(a) Bob Motta, groundskeeper, City of Pacific Grove. Use of pesticides.

(b) United States Coast Guard, Monterey. Activities at Coast Guard jetty.

(c) Fred Guild, Assistant Harbormaster, Monterey Harbor. Boat basin regulations.

(d) Fuel dock attendant, Wharf #2, Monterey Harbor.

(e) Mr. Ed Derowski, Public Works, City of Pacific Grove.

XI. Land Vegetation

1. Engineering-Science, Inc. 1974. Draft Environmental Impact Report for the Proposed Stage 1 Pacific Grove-Monterey Consolidation Project of the Regional Sewage System. Berkeley, California. 36 pp. appendices.

Lists native vegetation and describes briefly landscaping in Perkins and Shoreline Park.

2. Local Sources of information:

(a) Bob Motta, groundskeeper, City of Pacific Grove. Landscaped parks.

(b) Pacific Grove Natural History Museum. Native vegetation.

XII. Hopkins Marine Station unpublished undergraduate papers, 1970. Note:

The following papers relate to the effects of the Pt. Pinos sewage discharge on the nearshore biota. It should be noted that the effluent was heavily chlorinated at the time, and exhibited a much higher chlorine residual than it does now. Therefore, the following papers are useful primarily in that they document the toxic effects of chlorine on the local biota. Available at Hopkins Marine Station.

1. Anderlini, Victor. The effects of a marine sewage outfall on the natural succession of invertebrate larval settelment.

Author placed settling surfaces at six stations 10-60 meters offshore Pt. Pinos outfall, and collected them over a period of four days. Concluded, upon examination of slides, that detrital cover was inhibiting "natural succession of early substrate colonizers" at station 10 meters from outfall, and that nutrient enrichment 30-40 meters from outfall possibly accelerated and enhanced natural succession.

2. Anselmo, Elaine. An analysis of the distribution of Anthopleura elegantissima in relationship to the presence of a sewage outfall.

Based on field and laboratory observations, author concluded (1) abundance of A. elegantissima varies directly with strength of Pt. Pinos outfall sewage field, as measured by chlorine and phosphate strengths; (2) chlorinated sewage has a much greater toxic effect on A. elegantissima than unchlorinated sewage and (3) the toxicity of sewage is exhibited in the anemones' decreased ability to adhere to a granite substrate.

3. Baldo, Angelo Louise. A study of inshore phytoplankton distribution near a sewage outfall.

Author compares phytoplankton counts from 8 nearshore and 5 offshore stations, sampled weekly during April-May, 1970. Counts are higher at the outfall side of Pt. Pinos than at the eastward (ASBS) side, and higher at nearshore stations than at offshore stations. Three offshore stations were at Pt. Pinos and two within the ASBS. In laboratory experiments author found the growth of two species of diatoms were inhibited to different degrees by chlorinated (Pacific Grove) and unchlorinated (Monterey) sewage.

4. Clearman, David A. The effect of primary treated sewage on the distribution and abundance of microfauna on Endocladia muricata, Prionitis lanceolata, and Corallina vancouveriensus.

Author found that the Pt. Pinos discharge had a most marked effect on distribution of microfauna associated with Priontis lanceolata and Corallina vancouverianous , red algae found in mid and low intertidal areas respectively. Gradients in abundance of certain invertebrate species corresponded with gradients of water quality parameters used to characterize and locate the sewage field. Physical-chemical tests indicated that effluent-containing water passed to the east (ASBS) side of Pt. Pinos on high tides only, and therefore affected on this side the abundance and distribution of microfauna associated with E. muricata, the algae species found in the high intertidal.

5. Clearman, David A. Abundance and distribution of microfauna on Prionitis lanceolata as an indicator of marine pollution.

Author compared abundance and distribution of microfauna on Prionitis lanceolata during the summer at Pt. Pinos stations with stations at a similarly exposed and oriented rocky promontory 1000 meters south of Pt. Pinos. He found that the outfall stations showed a variation in distribution and abundance of microfauna beyond that attributed to seasonal variation (as existed between his spring and summer sampling of the Pt. Pinos stations) and natural variation (as existed at his "control" stations to the south).

6. Hainsworth, John. The effect of turbidity caused by sewage pollution on the productiveness of Iridaea flaccida, Phyllospadix torreyi and Laminaria setchellii.

Author studied the effect of various dilutions of Pt. Pinos outfall receiving water on the productivity of three floral species with pigments absorbing light of different wavelengths. He found that the sewage-containing water absorbed light at the same wavelength required for photosynthesis by P. torreyi and L. setchellii. Therefore, the productivity of these two species was more impaired than that of I. flaccida, which utilizes light of a different wavelength for photosynthesis. His observations on the distribution of these species near the outfall, relative to measurements of turbidity, are consistent with the conclusions reached in his laboratory experiments.

7. Holstrom, Marshall. Distribution, reproduction, recruitment and pigments of the stalked barnacle Pollicipes polymerus in the vicinity of sewage outfalls at Pacific Grove and Carmel, California.

Author compared the reproduction and recruitment of Pollicipes polymerus at various stations near the Pt. Pinos outfall and along the shoreline east to Cabrillo Point. There was a statistically significant difference between those stations just adjacent to the outfall, and on the northeast (ASBS) side of Pt. Pinos; there was no such significant difference between the east-Pt. Pinos stations and other Pacific Grove stations, showing the effect of the sewage on these parameters is highly localized. Author also compared quantity and composition of hemolymph and found three of the six carotinoid pigments normally present were absent in the hemolymph of barnacles closest to the outfall. Barnacles just east of the outfall contained lesser quantities of the hemolymph than barnacles at Cabrillo Point. Author states heavy chlorination (up to 45 ppm residual) at Point Pinos is probably responsible for the poorer status of the barnacle population, as compared with the population adjacent to the Carmel outfall.

8. McCabe, Melanie Ann. The effects of sewage on the righting response of the hermit crab Pagurus samuelis (Stimpson, 1857).

Author shows by three different tests that Pagurus samuelis exposed to sewage take significantly longer to right themselves than do those from unpolluted waters. The speed of righting decreased significantly when dilution of sewage was 2%, the concentration existing at the Pt. Pinos outfall receiving waters. As a fast righting response is a definite adaptive feature, the author suggests that its lack could explain the absence of P. samuelis within 80' of the Pt. Pinos outfall.

in the brown algae showed a decrease corresponding to the strength of the sewage field at the collecting station. Author suggests brown algae could be used as an indicator of sewage distribution.

14. Stibbs, Henry H. Chromium concentrations in tunicates (Urochordata: Ascidiacea) taken near Monterey, California. Relation to local sewage outfalls.

(1) Author determined the chromium concentration in Monterey sewage to be .008; the concentration of chromium in Pacific Grove and Carmel effluent was not detectable (detection limit: .004 ppm). Chromium concentration in seawater east of Hopkins Marine Station was found to be .095 ppm.

(2) Author determined chromium content in different genera of ascidians collected from the Monterey marina, Hopkins Marine Station and the Carmel and Pt. Pinos outfall areas. Uptake of chromium varied greatly between genera, and concentrations were lower in animals from the Pt. Pinos area. Author postulates that the lower concentrations at Pt. Pinos could be due to heavy chlorination, which interferes with the feeding process and/or reduces the plankton populations on which the ascidians feed.

APPENDIX 1

Species List from Subtidal Survey of ASBS Conducted 10/7/77-11/22/77

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Length of transect (meters)			60	340	60	340	60	60	
Exposure			SE	SE	SE	TR	EX	EX	
Percentage Sand			22%	50%	26%	29%	8.3%	8.3%	
Transect Depth			29-35'	27-48'	30-33'	13-57'	22-33'	31-45'	
MARINE FLORA									
Division Phaeophyta									
Macrocystis pyrifera adults	All	Rock	4	23	10	14	4	7	
Average # of stipes	-		4	-	18	7	13	24	
Juveniles	All		2	1	2	8	0	0	
Cystoseira osmundacea	All	Rock tops	P	P	P	P	P	P	
Desmarestia ligulata	All	Rock tops		P	P				
Dictyoneuropsis reticulata	All	Rock tops	P	P	P	P	P	P	
Laminaria dentigera	In	Rock tops	P	P	P		P		
Division Rhodophyta									
Botryocladia pseudodichotoma	All	Low rocks	P	P	C	P	C	P	
Botryoglossum farlowianum	All	Rock tops	P	C	P	P	A	P	
Callophyllis spp. (C. flabellulata, C. violacea)	All	Rock tops	P	C	A	P		P	
Gelidium robustum	In	Rock tops				P	P		
Gigartina harveyana	In	Rock tops		P					

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Gigartina spp.	In	Rock tops	C	C	A	C	A	C	
(*G. corymbifera*)									
(*G. exasperata*)								P	
Gonimophyllum skottsbergii	-	Epiphyte							X
Grateloupia doryphora	-							P	
Microcladia coulteri	In	Epiphyte/rock				P			
Neoptiloda densa	In	Rock tops				P			
Plocamium cartilagineum	-	Rock tops	P		P	P			
Prionitis australis	-	Rock tops				P			
P. lanceolata		Rock tops				P	P	P	
Rhodymenia spp. (*R. californica* var. *californica*, var. *attenuata*; *R. pacifica*)	All	Rock tops	A		A	C	C		
Weeksia reticulata	-	Rock tops						P	
Articulated corallines	All	Rock tops	C	C		C	A	A	
Encrusting corallines	All	Rock tops	10%	15%	20%	20%	50%	80%	
Filamentous red algae	All	Rock tops	P	P	C	P			
Red crust	All	Rock tops	P	P	P	P	P	P	
Phylum Porifera									
Acarnus erithacus	All	Rock	P	C		P			
?*Axocielita originalis*	-								X

APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Cliona celata	In	Boring in $CaCO_3$	P			P		C	X
Hymenamphiastra cyanocrypta	All	Rock/crevices	P	P	C	P	P	P	
Leucandra heathi	-								X
Leucilla nuttingi	-								X
Leucosolenia eleanor	-								X
Polymastia pachymastia	All	Sand covered rock		P		P		P	
Spheciospongia confoederata	-								X
Stelletta clarella	-								X
Tethya aurantia	All	Rock tops	C	P	P	P	P		
Tettila arb	-								X
Xestospongia vanilla	-								X
Unidentified species	All	Various	P	P	P	P	P	P	
Phylum Cnidaria (Coelenterata)									
Abietinaria spp.	All	Algae/rocks	P	C		P	P	P	
Aglaophenia spp.	-	Algae/rocks				P	P		
Anthopleura artemsia	In		P	P		P			
A. elegantissima	In	Sand/gravel	P	P	P	P	C		
A. xanthogrammica	In	Rock							
Astrangia lajollaensis	All	Rock faces	P	C	C	P			

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Balanophyllia elegans	All	Rock	P	A	P	A	C	P	
Campanularia sp.	-								X
Clavularia sp.	-						P		
Corynactis californica	All	Rock faces	P	C	P	C	P	P	
Epiactis prolifera	In	Rocks/algae				P	P		
Eucopella spp.	In	Algae				P	P		X
Metridium senile	Off	Rock							X
Pachycerianthus sp.	-	Sand		P	P				
Paracyathus stearnsi	Off		P	P		P		P	
Plumularia sp.	In	Algae					P	P	
Sertularella sp.	In	Rocks algae	P	P		P	P	P	
Sertularia sp.	-								X
Tealia coriacea	In	Sandy gravel					P		
T. lofotensis	Off	Rock outcrops	P	P		P	P	P	
T. sp.	Off		P		P	P	P	P	
Tubularia sp.									X
Phylum Nemertea									
Tubulanus polymorphus	-	-							X
T. sexlineatus	-	-							X

APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Phylum Sipuncula									
Themiste dyscritum	-	-							X
Phylum Annelida									
Class Polychaeta									
Diopatra ornata	All	Sand	C	A	P	P			
Dodecaceria fewkesi	All	Rock	P	P	P	C	A	P	
D. fewkesi (large form)	All	Rock		C	P	P			
Eudistylia polymorpha	All	Crevices	P	P	P	P	A	A	
Myxicola infundibulum	-								X
Phragmatopoma californica	In	Rocks in sand areas	C	P	P	P	P		
Sabellaria sp.	-	Rock		P		P	P		
Salmacina tribranchiata	All	Rock		P	P	P		P	
Serpula sp.	-	Rock	P		P				
Spirorbis spp.	-	Algae	P		P				
Thelepus crispus	-	Sand							X
Phylum Mollusca									
Class Polyplacophora									
Cryptochiton stelleri	In	Rocks	C	P	P	P	P	P	
Tonicella lineata	All	Coralline crusts			P	P	C	P	

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Class Gastropoda									
Sub Class Prosobranchia									
Astraea gibberosa	-	Rock						P	
Calliostoma annulatum	-	Algae esp Cystoseira							X
C. canaliculatum	-								X
C. ligatum	-	Rock/tunicates	P	P	P	C	P	P	
C. supragranosum	-								X
Ceratostoma foliatum	-	Barnacle covered rock							X
Diodora aspersa	-								X
Erato sp.	-								X
Haliotis spp. (H. rufescens) (H.walallensis)	-	Crevice	P					P	
Hipponix sp.	-	Rock or shell							X
Lamellaria sp.	-	Colonial tunicates							X
Megatebennus bimaculatus	-	Colonial tunicates							X
Megathura crenulata	All	Rock/tunicate	P	P	P	P		P	
Mitra idae	-	Rock	P		P	P	P		
Ocenebra sp.	-	Rock							X

APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Petaloconchus montereyensis	All	Rock	P	A	C	C	P	P	
Pseudomelatoma sp.	-	Rock							X
Serpulorbis squamigerus	-	Rock or shell							X
Tegula spp. (T. montereyi, T. brunnea, T. pulligo)	All	Macrocytis and Laminaria/Cystoseira Other algae	A	P	P	P	C		
Class Gastropoda									
Sub Class Ophistobranchia									
Anisodoris nobilis	-	Rock							X
Aplysia californica	-	Rock sand algae							X
Archidoris montereyensis	-	Rock							X
A. odhneri	-	Rock							X
Cadlina luteomarginata	-	Rock							X
Coryphella trilineata	-	Rock							X
Diaulula sandiegensis	-	Rock							X
Doriopsilla albopunctata	-	Rock							X
Flabellinopsis iodinea	-	Rock							X
Hermissenda crassicornis	-	Rock							X
Hopkinsia rosacea	-	Rock							X

APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Laila cockerelli	-	Rock							X
Phidiana pugnax	-	Rock							X
Trinchesia lagunae	-	On Sertularia							X
Triopha carpenteri	-	Rock							X
T. grandis	-	Rock							X
Phylum Bivalvia									
Hinnites giganteus	-	Rock			P		P		
Phylum Arthropoda									
Class Crustacea									
Alpheus sp.	-								X
Balanus nubilus	-		P		P				
Balanus sp.	All		P	C	A	P	P	P	
Cryptolithodes sitchensis	-	Sand/rock					P		
Loxorhynchus spp. (L. grandis, L. crispatus)	All	Rocks	P	P	P	C	P	P	
Mimulus foliatus	-	Rocks, Diopatra	P		P	P			
Pachycheles sp.	-	Holdfasts							X
Pandalus gurneyi	-								X
Pagurus spp.	-								X

APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Phyllolithodes papillosus	-	Under rock/algae	P		P				
Pugettia producta	-		P		P				
P. richii	-		P						
Scyra acutifrons	-		P		P				
Phylum Ectoprocta (Bryozoa)									
Bugula spp.	-	Rock							X
Celleporaria brunnea	-	Rock							X
Costazia robertsonae	All	Rock, algae	C	C	P	A	P	P	
Crisia sp.	-	Algae				P			
Cryptosula pallasiana	-	Rock	C	P	P	A	C	P	
Eurystomella bilabiata	-					P	P		
Flustrellidra corniculata	-								X
Hippodiplosia insculpta	All	Rock, algae	P	A	P	P		P	
Hippothoa hyalina	All	Rocks,shells,algae		P	P	P		P	
Lagenipora sp.	All		P	C	P	C	P	P	
Membranipora spp.	-	_Macrocystis_							X
Phidolopora pacifica	All	Rock,algae	P	C	C	P	P	P	
Scrupocellaria sp.	-					P		P	X
Thalamoporella sp.	-								X

APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Tubulipora spp.	-								X
Unidentified species									
Phylum Echinodermata									
Class Asteroidea									
Astropecten verrilli	Off	Sand		P	P	P			
Dermasterias imbricata		Rock							X
Henricia leviuscula	Off	Rock	P	P			P	P	
Leptasterias spp.	-								X
Orthasterias koehleri	All	Rock		C	P	P	P	P	
Patiria miniata	All	All	A	A	A	C	A	A	
Pisaster brevispinus	-	Sand & rock			P	P			
P. giganteus	All	Rock	C	C	P	C	C	P	
P. ochraceus	In	Rock	P		P				
Pycnopodia helianthoides	All	All	P	P	P		P		
Class Holothuroidea									
Cucumaria miniata	All	Crevices		P	P		P	P	
?C. piperata	-	Crevices							X
Eupentacta quinquesemita	-	Crevices		P		P			
Stichopus californicus	-	Rocks	P	P	P		P		

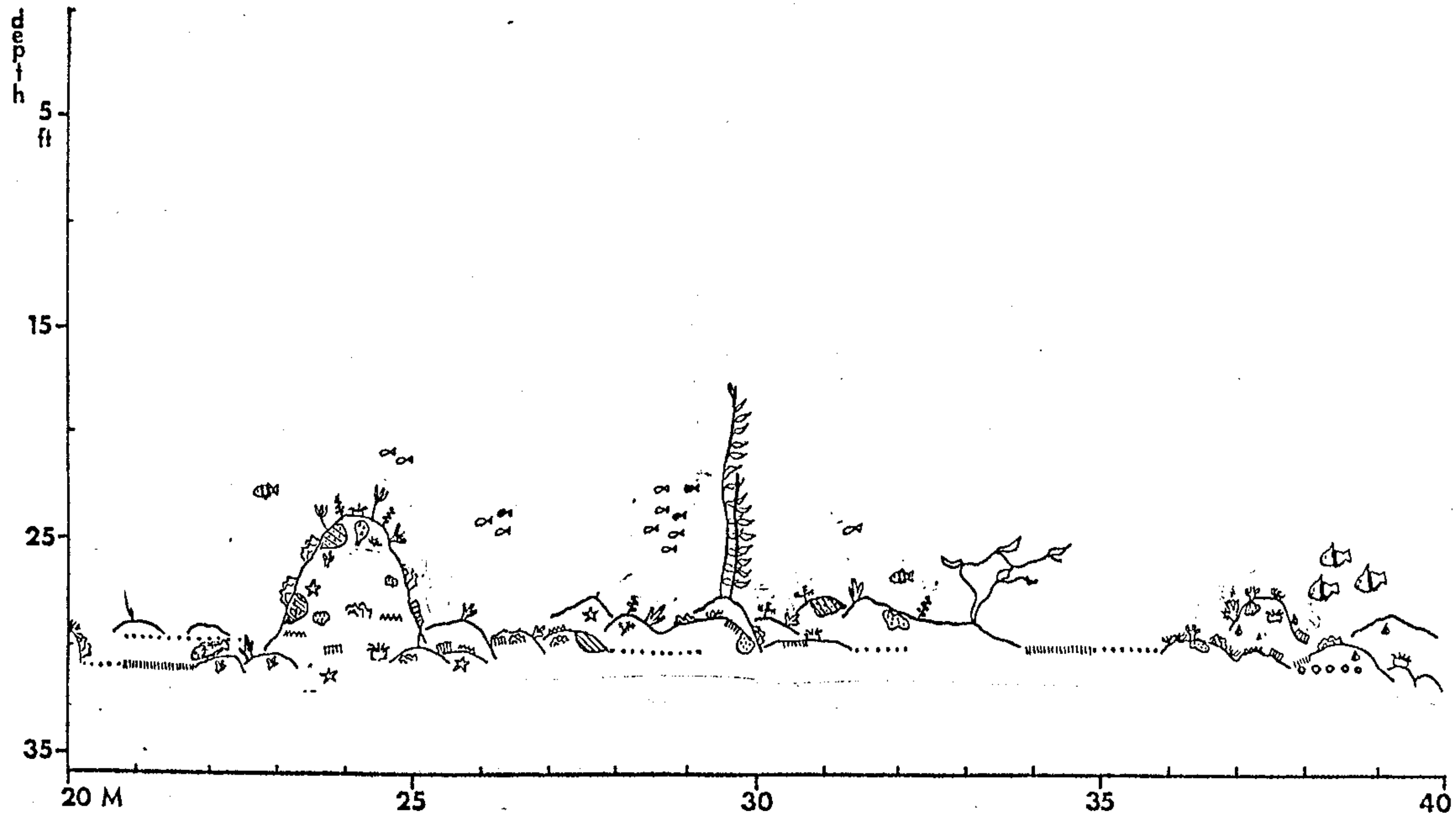
APPENDIX 1 Continued

Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Class Ophuroidea									
Ophioplocus esmarki	-	Crevices/under rock							X
Ophiopteris papillosa	-	Crevices/under rock							X
Ophiothrix spiculata	-	Under rock,holdfasts							X
Class Echnoidea									
Strongylocentrotus franciscanus	-	Crevices			P	C		P	
S. purpuratus	-	Crevices	P						
Phylum Chordata									
Subphylum Urochordata									
Aplidium spp.		Rock							
Archidistoma molle		Rock							
A. psammion	All	Rock	A	C	P	A	C		
Ascidia ceratodes		Rock				P	P		
Boltenia villosa		Rock							X
Cnedmidocarpa finmarkiensis		Rock							X
Cystodytes lobatus	Off	Rock,*Macrocystis*	P	C	P	P			
Didemnum carnulentun	All	Rocks,algae	P	P	C	C	P		
Diplosoma macdonaldi	-								X
Metandrocarpa taylori	-								X

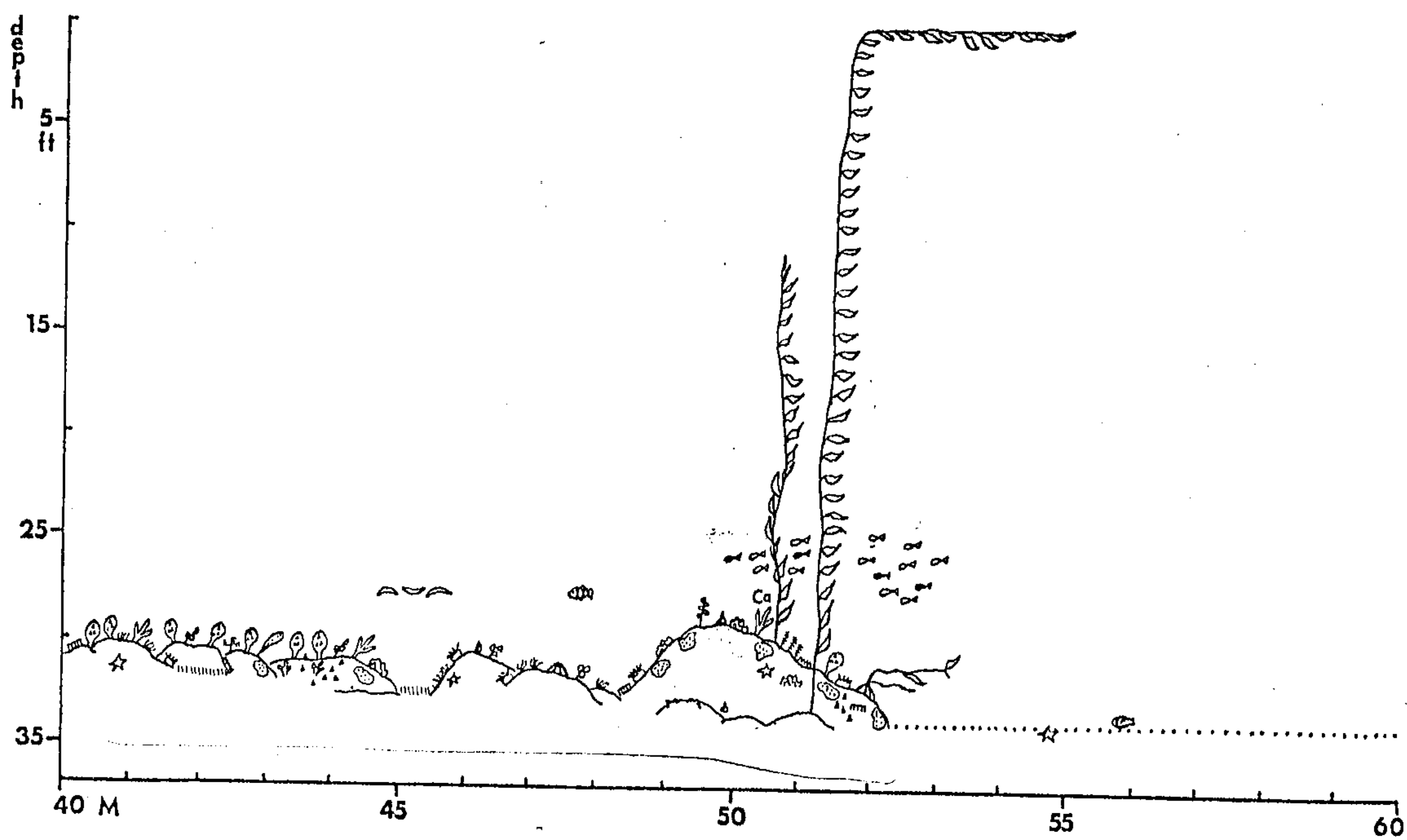
Species	Depth	Substrate	Green Gables	Lovers Point	East Otter	Otter Point	Lucas Point	Point Pinos	Present in ASBS
Perophora annectens	-	Various							X
Pycnoclavella stanleyi	In		P	P	P	P			
Pyura haustor	In		P	P	P	P			
Ritterella rubra	-								X
Styela montereyensis	In	Rock	P	P		C	A	P	
S. truncata	-								X
Synoicum parfustus	-					C	P	P	
Trididemnum opacum	All		C			P	P		
Unidentified species			P	P	P	P			
Class Pices									
Scorpaenidae (rockfish)									
Sebastes atrovirens	Off	Rock		3		6			
S. mystinus	Off	Rock						1	
S. mystinus (juvenile)	All	Rock & sand	30	A	102	53	44	P	
S. paucispinus juvenile		Rock		P		7	3		
Unidentified juvenile rockfish		Rock & sand	9	P	3	2	21	P	
Embiotocidae (perch)									
Embiotoca jacksoni	In	Kelp bed	3	C	1	1	2	1	
E. lateralis	In	Kelp bed	3			1	2		

APPENDIX 2, continued

Green Gables Transect, 20 to 40 meters
Legend for figures on pages 134-136

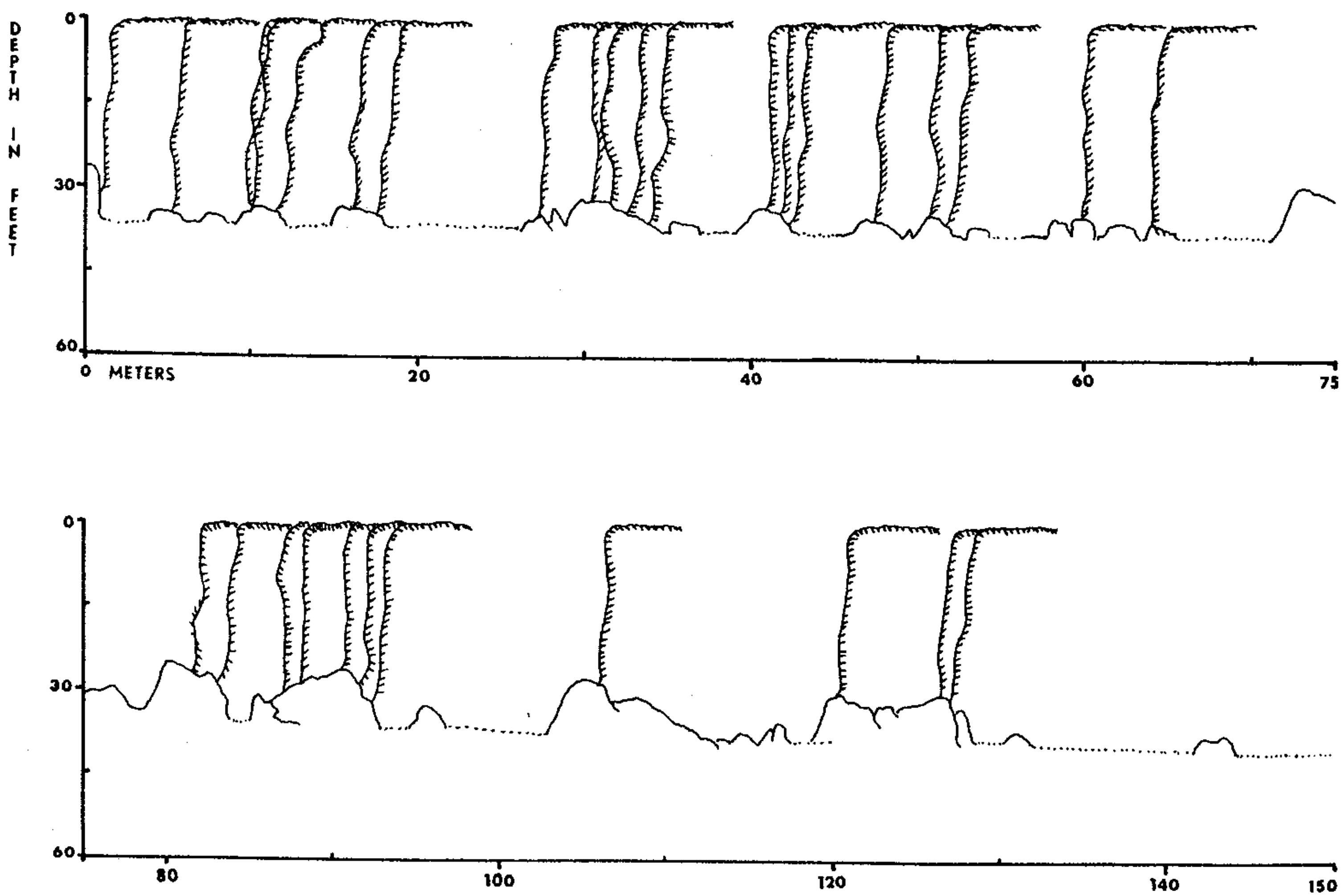


Green Gables Transect, 40 to 60 meters
Legend for figures on pages 134-136



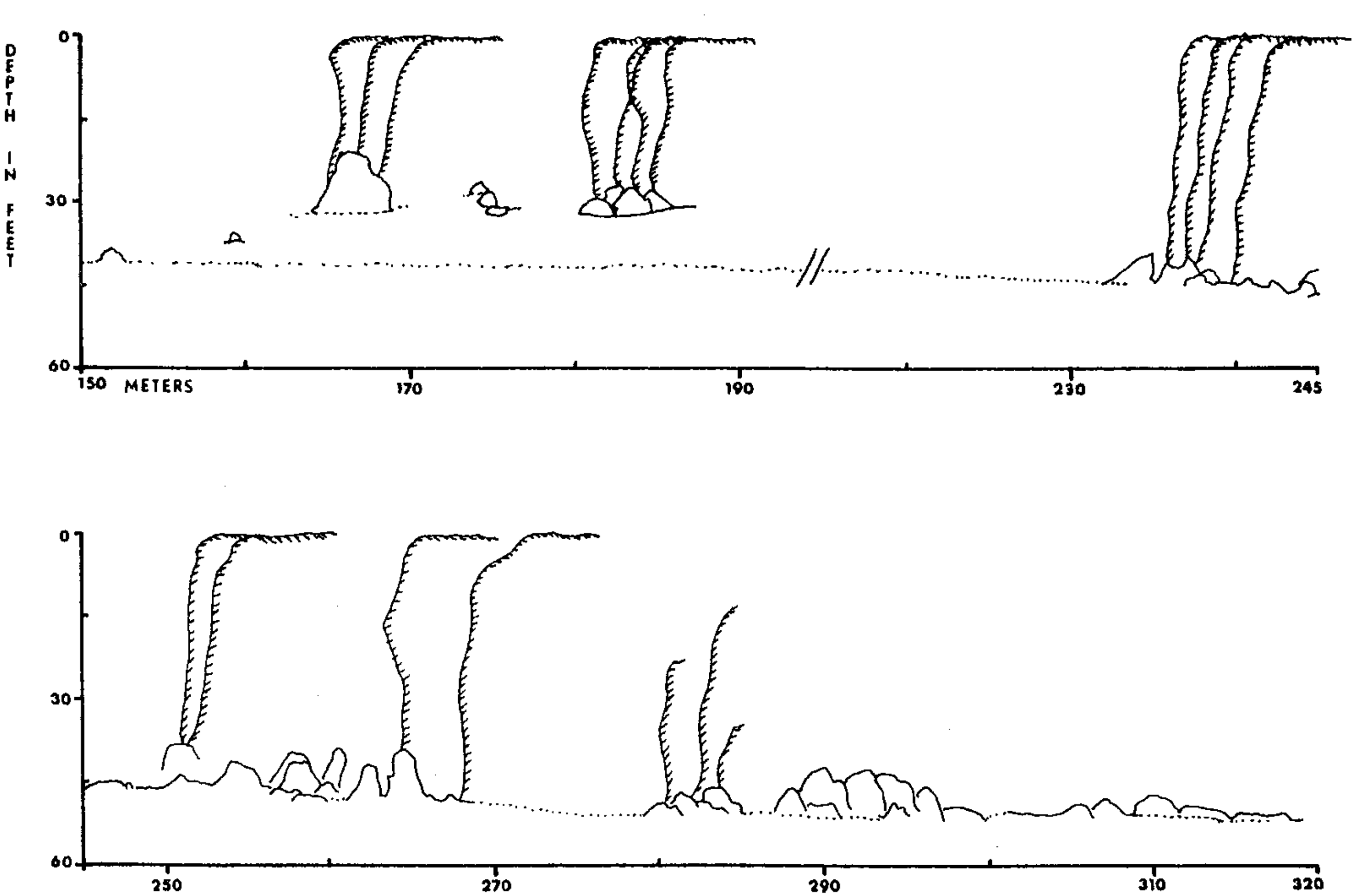
APPENDIX 2, continued

LOVERS POINT TRANSECT, 0 to 150 METERS
Legend for figures on pages 134-136



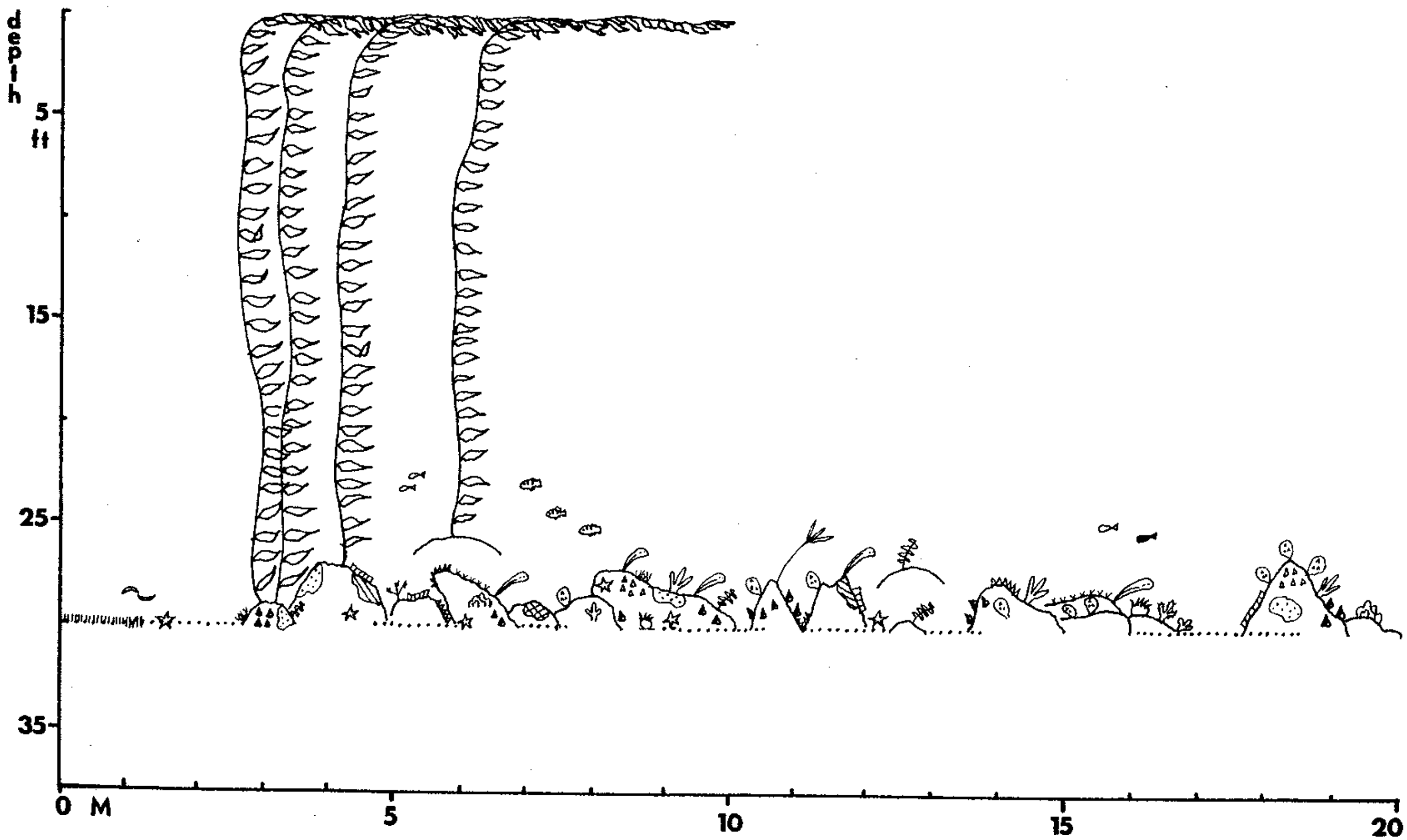
APPENDIX 2, continued

LOVERS POINT TRANSECT, 150 to 320 METERS
Legend for figures on pages 134-136

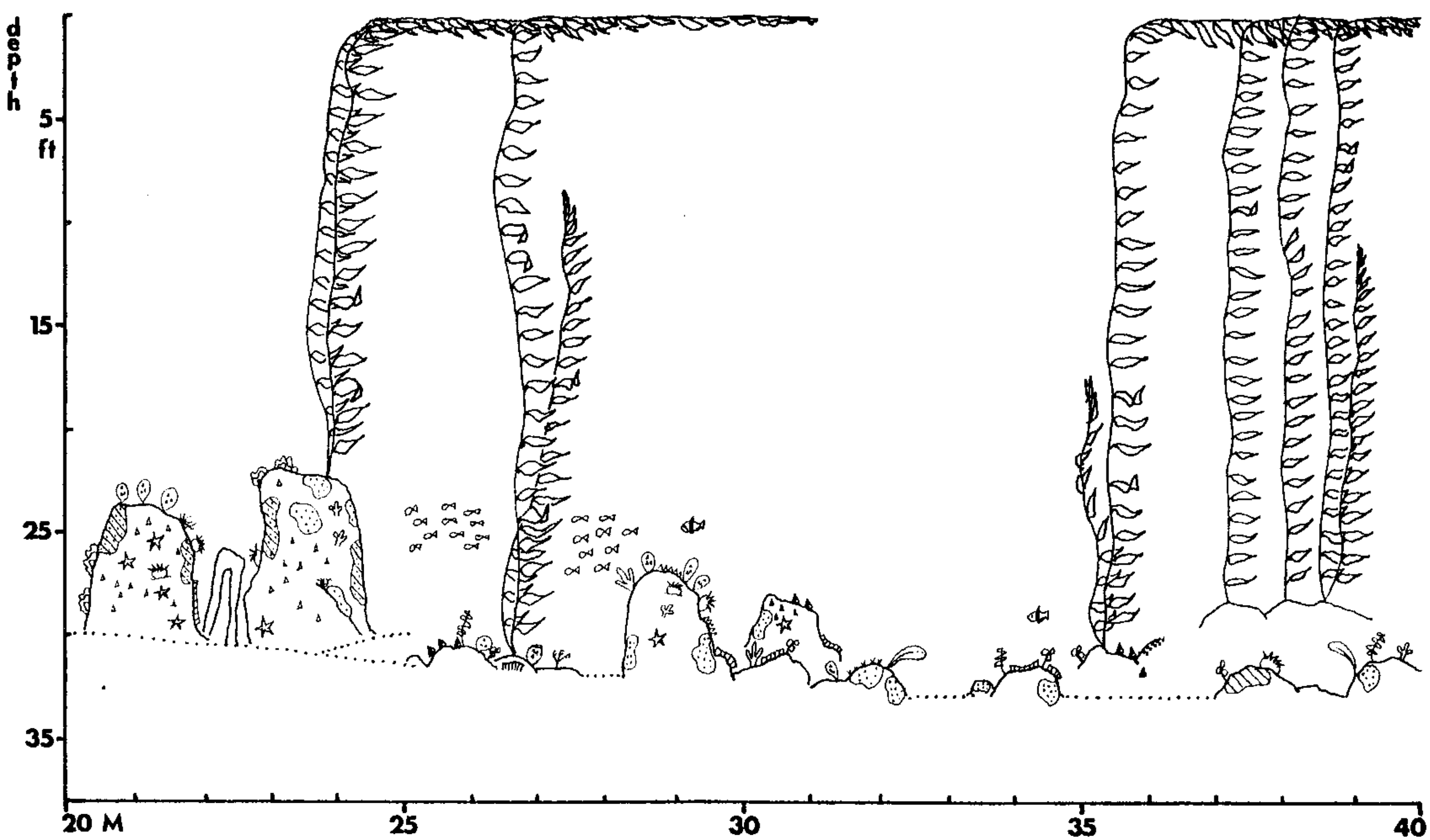


APPENDIX 2, continued

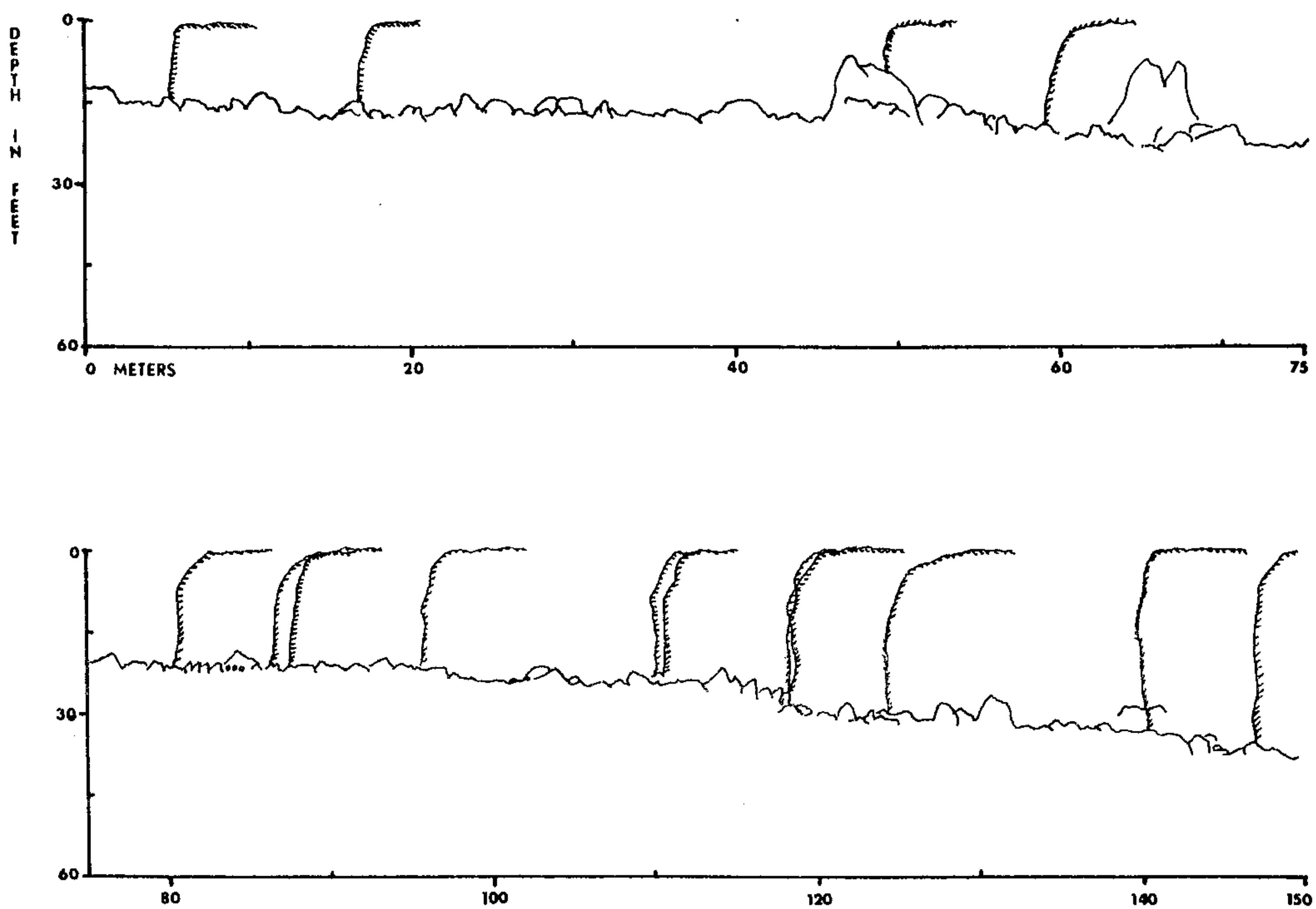
EAST OF OTTER POINT TRANSECT, 0 to 20 METERS
Legend for figures on pages 134-136



EAST OF OTTER POINT TRANSECT, 20 to 40 METERS
Legend for figures on pages 134-136

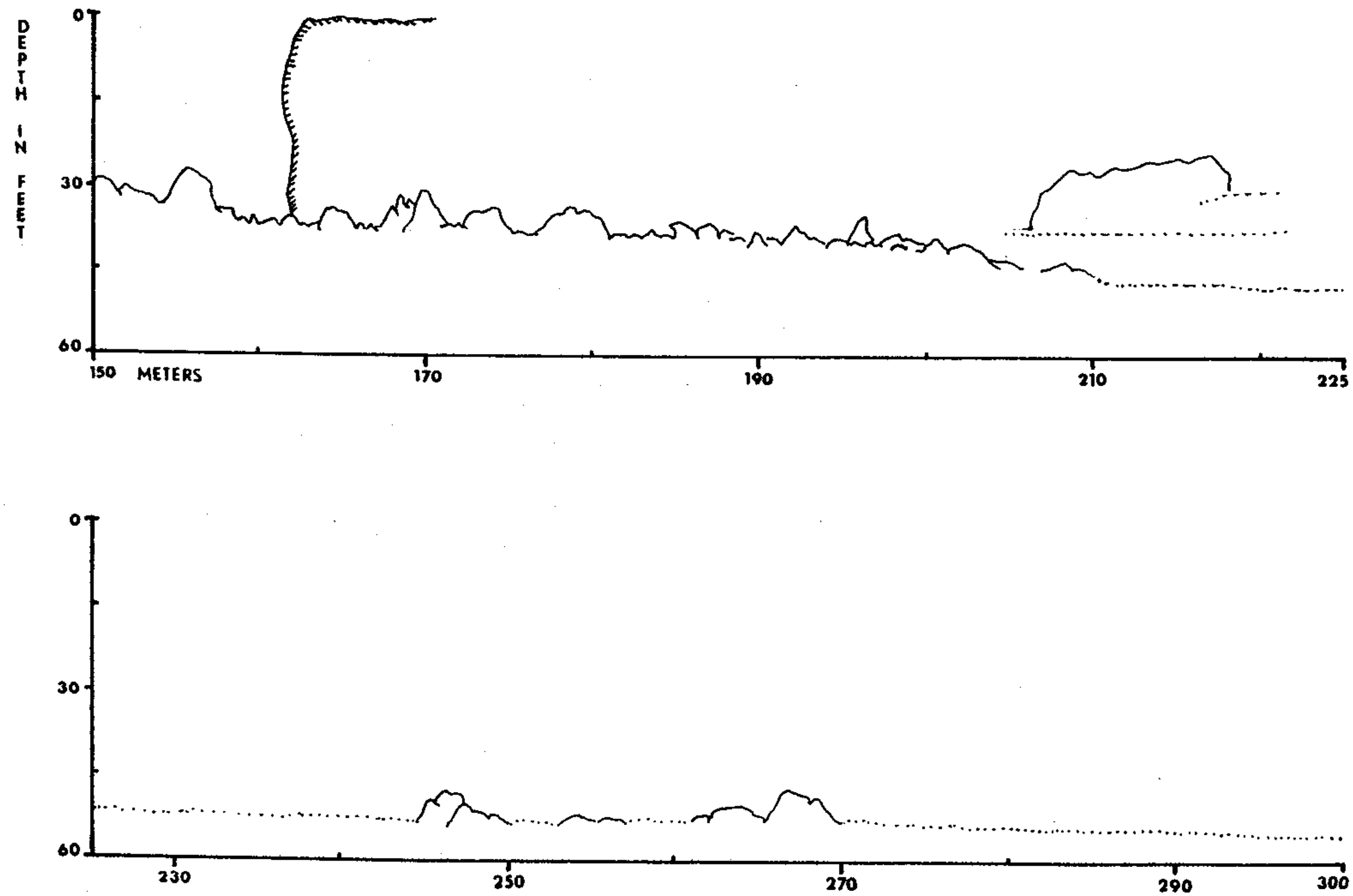


OTTER POINT TRANSECT, 0 to 150 METERS
Legend for figures on pages 134-136



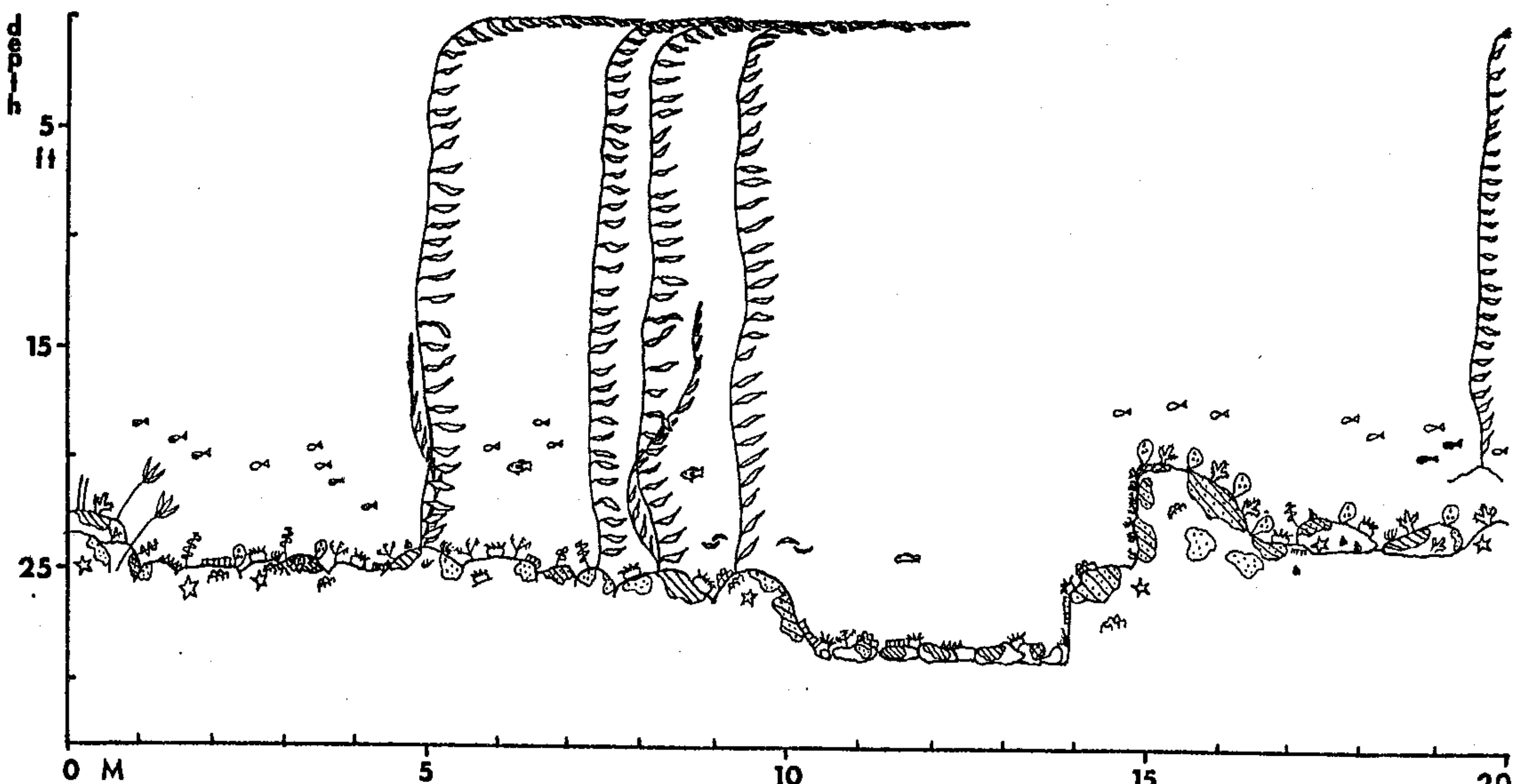
APPENDIX 2, continued

OTTER POINT TRANSECT, 150 to 300 METERS
Legend for figures on pages 134-136



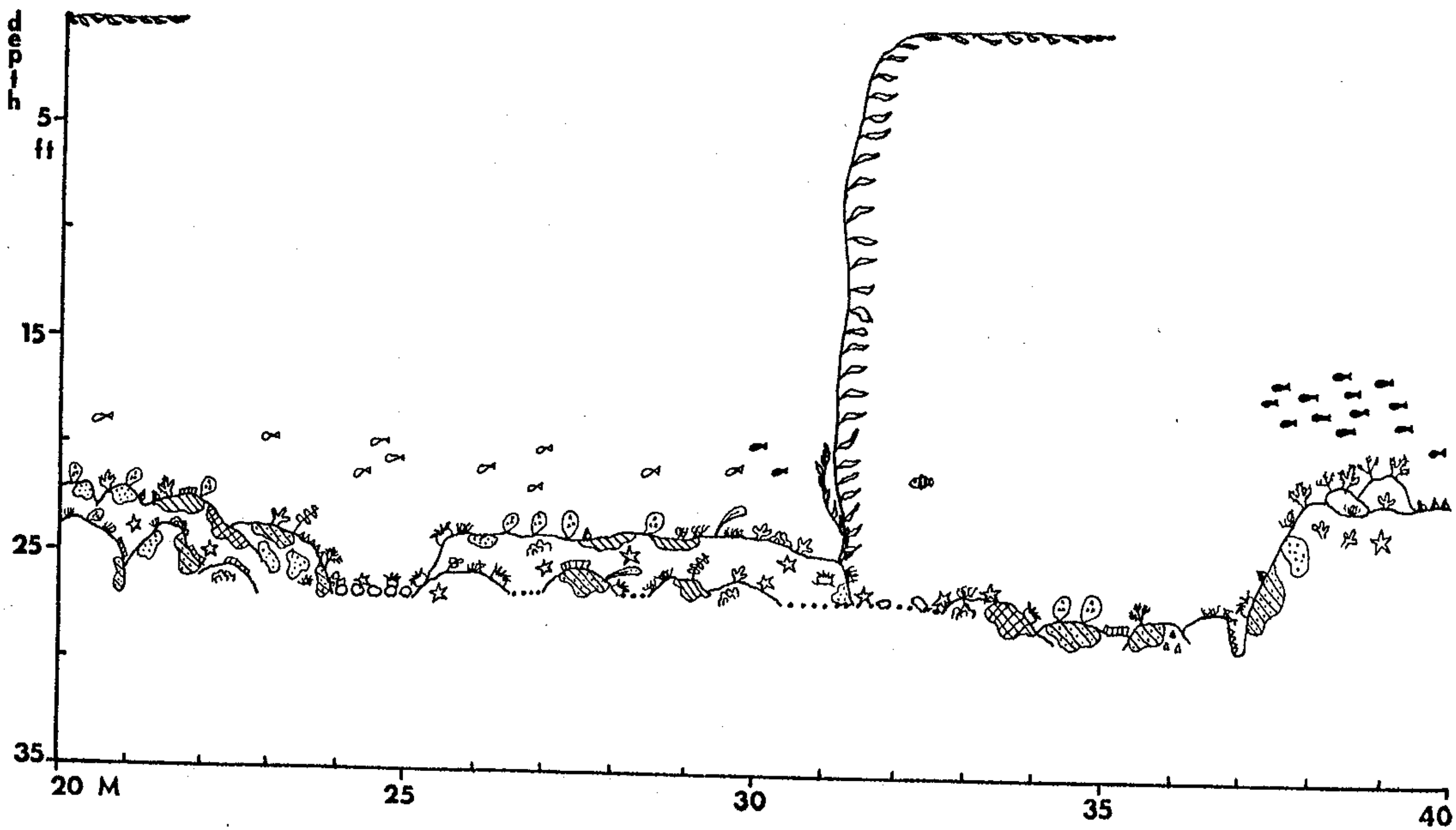
APPENDIX 2, continued

LUCAS POINT TRANSECT, 0 to 20 METERS
Legend for figures on pages 134-136

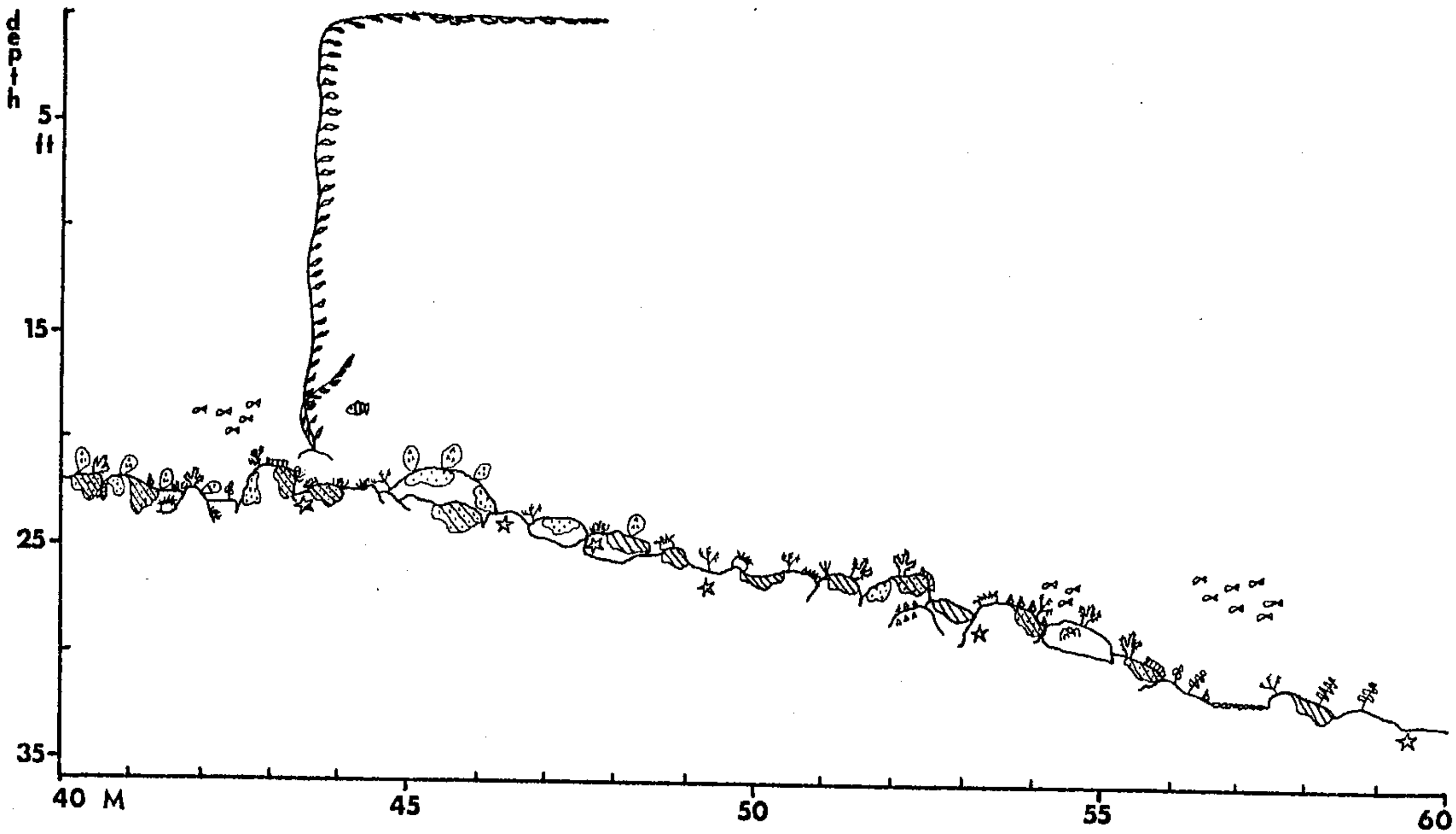


APPENDIX 2, continued

LUCAS POINT TRANSECT, 20 to 40 METERS
Legend for figures on pages 134-136

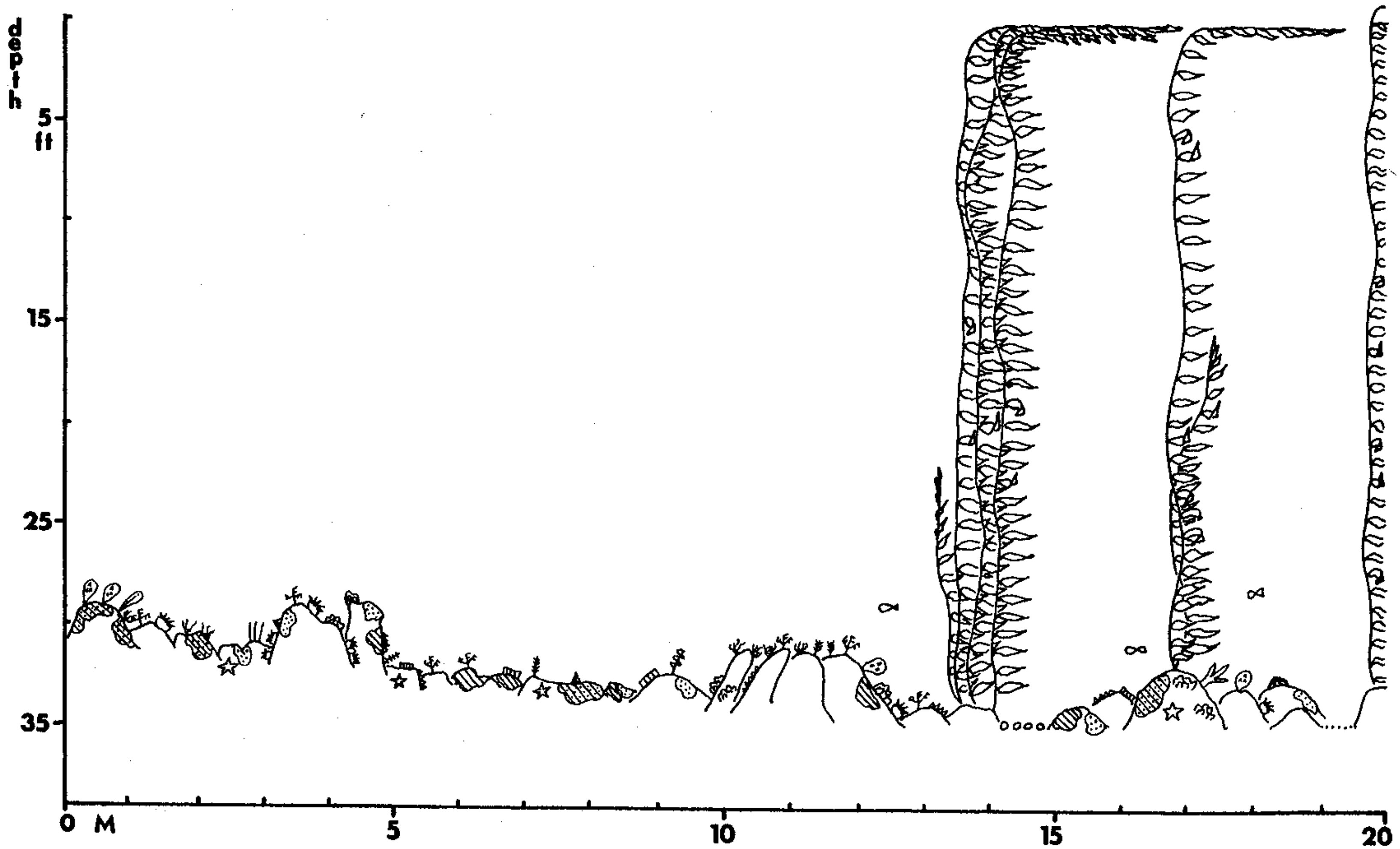


LUCAS POINT TRANSECT, 40 to 60 METERS
Legend for figures on pages 134-136



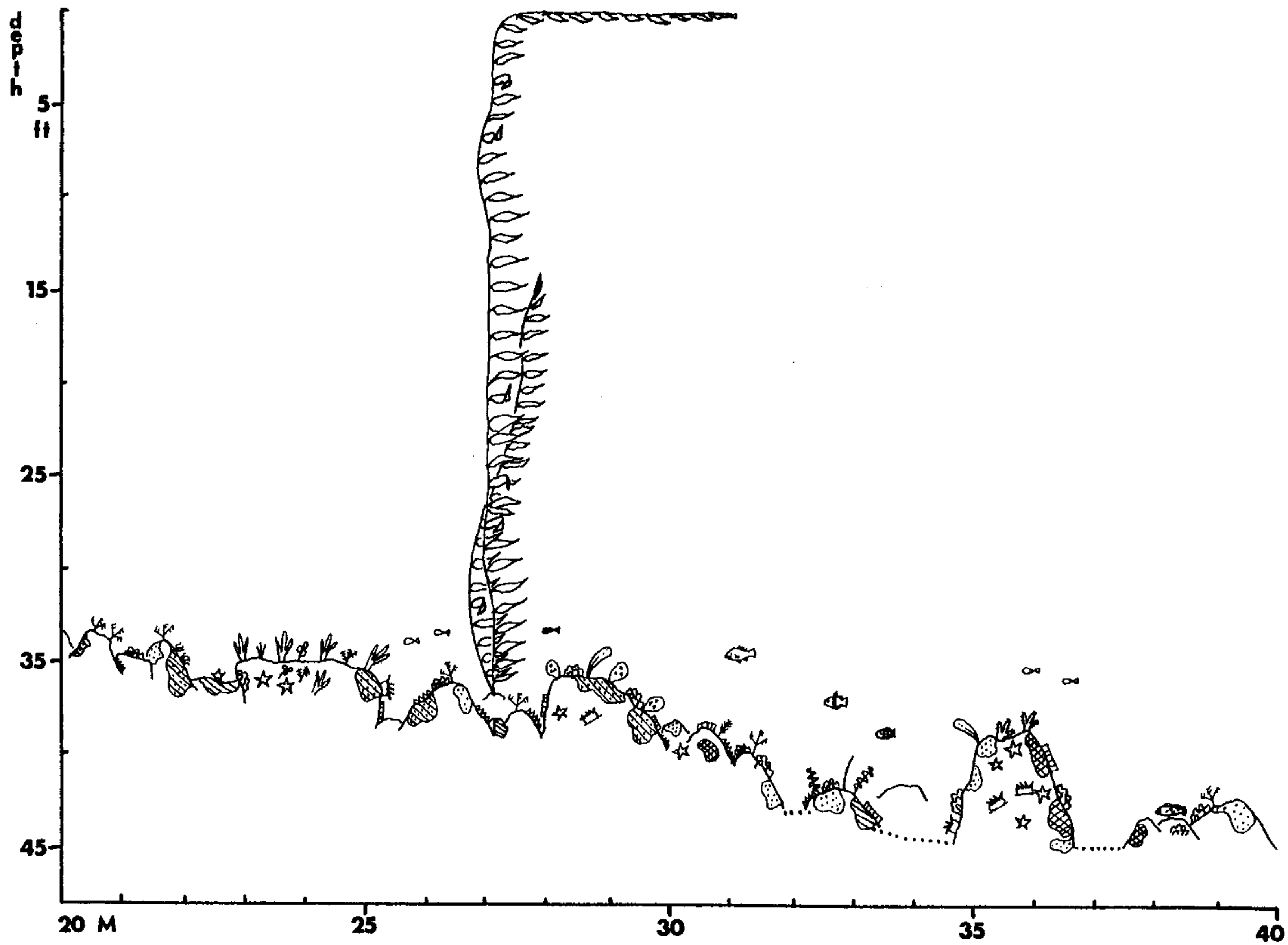
APPENDIX 2, continued

POINT PIÑOS TRANSECT, 0 to 20 METERS
Legend for figures on pages 134-136



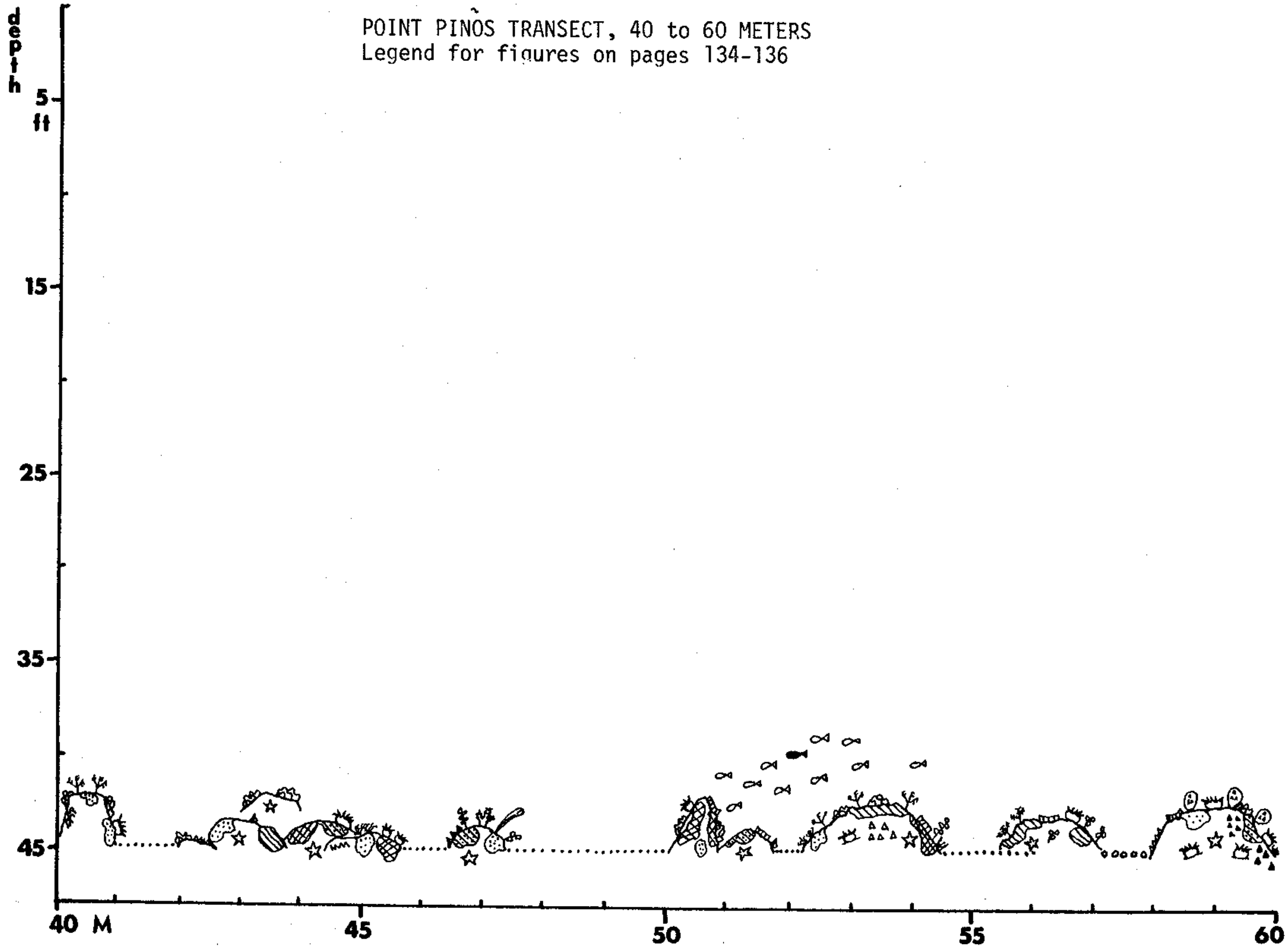
APPENDIX 2, continued

POINT PIÑOS TRANSECT 20 to 40 METERS
Legend for figures on pages 134-136



APPENDIX 2, continued

POINT PIÑOS TRANSECT, 40 to 60 METERS
Legend for figures on pages 134-136



APPENDIX 2, continued: Legend for subtidal figures

ALGAE

PHAEOPHYTA (BROWNS)

Cystoseira osmundacea 

Dictyoneuropsis reticulata 

Laminaria dentigera 

PHODOPHYTA (REDS)

Botryocladia pseudodichotoma 

Botryoglossum farlowianum 

Callophyllis spp. 

Gigartina sp. 

Prionitis sp. 

Plocamium cartilagineum 

Rhodymenia sp 

Articulated corallines 

Drift 

Encrusting corallines 

Encrusting corallines with Dodecaceria 

Holdfast 

Filamentous reds 

Red crust 

PORIFERA (SPONGES) 

Acarnus erithacus

Tethya aurantia

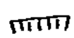
Hymenamphiastra cyanocrypta

Polymastia pachymastia

Unidentified species

Cliona celata

COELENTERATA

CORALS 

Astrangia lajollaensis

balanophyllia elegans

Paracyathus stearnsi

ECTOPROCTA (BRYOZOA) 

Hippodiplosia insculpta

Costazia robertsonae

Hippothoa hyalina

Phidilopora pacifica

Lagenipora sp.

Cryptosula pallasiana

Unidentified species

Eurystomella bilabiata

ANEMONES 

Tealia lofotensis

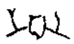
Tealia coriacea

Tealia sp.

Anthopleura elegantissima

Corynactis californica

Pachycerianthus sp.

ANNELIDA 

Dodecaceria fewkesi

D. fewkesi (large form)

Salmacina tribranchiata

Sabellaria sp

Diopatra ornata

Eudistylia ornata

Spirorbis spp.

Phragmatopoma californica

HYDROIDS 

Abietinaria spp.

Sertularella spp.

Plumularia spp.

Aglaophenia spp.

FISH
SCORPAENIDAE (ROCKFISH)

Sebastes mystinus (blue rockfish) 

S. mystinue juvenile 

S. paucispinus juvenile (bocaccio) 

APPENDIX 3 Continued

Species	Abun	Zone	Substrate Rock	Epiphyte	Other
C. sakaii	SA	4	X	-	-
C. stimpsonii	F	-	X	-	Shells
Bryopsis corticulans*	F	3-4	X	-	Exposed to strong surf
B. hypnoides	o-a	3	X	-	-
Derbesia marina	F	4	X	-	Cryptochiton stelleri, corallines
Codium fragile	F-C	-	X	-	-
C. setchellii*	F	4	X	-	-
"Collinsiella tuberculata"	-	-	-	-	May be stage of Enteromorpha and/or Monostroma
"Gomontia polyrhiza"	F	-	-	-	May be stage of Monostroma or Ulva
DIVISION PHAEOPHYCEAE					
Order Ectocarpus					
Ectocarpus acutus var acucus*	F	4-sub	-	X	-
E. corticulatus	O	-	-	X	-
E. parvus	C	-	-	X	-
Feldmannia acuminata*	O	3	-	X	-
F. chitonicola*	C	3	-	-	Chiton or limpet shells
F. cylindrica*	F	3-4	-	X	Limpets
F. rhizoidea*	I	3	-	X	Wood, only from Pacific Grove
Giffordia mitchelliae	C	4	X	X	-
G. saundersii*	-	3	-	-	-
Spongonema tomentosum	I-F	-	-	X	-
Streblonema myrionematoides	C	3-4	-	X	-
S. penetrale*	-	3	-	X	Only from Pacific Grove
S. porphyrae*	C	4	-	X	-

APPENDIX 3 Continued

Species	Abun	Zone	Substrate: Rock	Epiphyte	Other
Order Chordariales					
Myrionema balticum	F	4	–	X	–
M. corunnae	O–A	4	–	X	–
Compsonema intricatum	–	3	–	X	–
Hecatonema primarium	C	4	–	X	–
Ralfsia	–	–	–	–	–
R. pacifica	C	2–3	X	–	–
Hapalospongidion gelatinosum*	C	1	X	–	–
Leathesia difformis	C	2–3	X	X	–
L. nana	C	2–3	–	X	–
Cylindrocarpus rugosus	C	2	–	–	–
Analipus japonicus	F–C	2	X	–	Exposed to heavy surf
Haplogloia andersonii	–	3–4	X	–	–
Order Dictyosiponales					
Coilodesme californica	C	4	–	X	–
C. plana	C–O	4	–	X	–
Punctaria hesperia*	O	4	–	X	–
Soranthera ulvoidea	C	3	–	X	–
Order Scytosiphonales					
Scytosiphon dotyi	O–F	2	X	–	Winter annual
S. lomentaria	A	3–4	X	–	–
Petalonia fascia	F	2–3	X	XX	–
Colpomenia bullosa*	O	3	X	–	–
C. peregrina	C	4	X	X	–
Order Sphacelariales					
Sphacelaria didichotoma	R	4–sub	–	X	–

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
Order Desmarestiales					
Desmarestia latifrons	F	4-sub	X	-	-
D. ligulata var. ligulata	A	4-sub	X	-	Wood
Order Laminariales					
Laminaria dentigera	C	4-sub	X	-	-
L. ephemera	I	4	X'	-	-
Costaria costata	C	4-sub	X	-	-
Alaria marginata	A	-	X	-	-
Eisenia arborea	-	4-sub	X	-	-
Egregia menziesii	C	3-sub	X	-	-
Lessoniopsis littoralis	C	4	X	-	Exposed to full surf
Dictyoneurum californicum	F	4-sub	X	-	-
Dictyoneuropsis reticulata*	I	4	X	-	-
Postelsia palmaeformis	a	3-4	X	-	Exposed to surf
Nereocystis luetkeana	F	-	-	-	-
Macrocystis pyrifera	F	-	X	-	-
Order Fucales					
Fucus distichus	A	2-3	X	-	-
Pelvetia fastigiata	A	2-3	X	-	-
Pelvetiopsis limitata	I	2-3	X	-	-
Hesperophycus harveyanus	A	2	X	-	-
Cystoseira osmundacea	O	4	X	-	-
Sargassum muticum	A	4-sub	X	-	Quiet water
DIVISION RHODOPHYTA					
Order Goniotrichales					
Goniotrichum alsidii	C	4-sub	-	X	-

APPENDIX 3 Continued

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
Pterocladia media	O	-	X	-	-
Order Cryptonemiales					
Farlowia conferta	C	4	X	-	Sandy areas
F. mollis	F	3-sub	X	-	Sandy areas
Pikea californica	F	4-sub	X	-	-
Cryoptsiphonia woodii	-	4	X	-	-
Dilsea californica	F	4-sub	X	-	-
Constantinea simplex	A	4-sub	X	-	-
Peyssonellia hairii	-	4	X	-	-
P. meridionalis*	C	-	X	-	Shells
Coriophyllum expansum	-	2-sub	X	-	Only from Monterey
Hildenbrandia dawsonii	F	2-3	X	-	-
H. occidentalis	C	2	X	-	-
H. prototypus	C	4-sub	X	-	-
Lithothammium aculciferum	O	IT-sub	X	-	-
L. californicum	C	IT-sub	X	-	-
L. crassiusculum	O	IT-sub	X	-	-
L. pacificum	C	-	X	-	Shells
L. phymatodeum	F	4-sub	X	X	Shells
Melobesia marginata	C	-	-	X	-
M. mediocris	C	-	-	X	-
Mesophyllum conchatum*	C	-	-	X	On corallines
M. lamellatum	C	IT-sub	X	X	On corallines
Clathromorphum parcum*	C	-	-	X	On corallines
Neopolyporolithon reclinatum	C	IT-sub	-	X	On corallines
Lithophyllum imitans	C	4-sub	X	-	-

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
L. lichenare	A	-	X	-	Surf
Tenarea ascripticia	C	4-sub	-	X	-
T. dispar	C	4	-	X	-
Pseudolithophyllum neofarlowii	C	-	X	-	-
Hydrolithon decipiens	C-F	-	X	-	Shells
Lithothrix aspergillum	A	4	X	-	Sandy areas, on animals
Corallina officinalis var. chilensis	C	4-sub	X	-	-
C. vancouveriensis	C	-	X	-	-
Arthrocardia silvae	A	-	X	-	-
Serraticardia macmillanii	A	-	X	-	Heavy surf
Bossiella sp.					
B. californica ssp californica	C	-	-	-	-
B. orbigniana ssp dichotoma	F	4	X	-	-
B. plumosa	C	4	X	-	-
Calliarthron cheilosporioides	F	4-sub	X	-	-
C. tuberculosum	C	4-sub	-	-	-
Gloiosiphonia capillaris	C	4	X	-	-
G. verticillaris	C	4	X	-	Sand scoured
Endocladia muricata	A	1-3	X	-	-
Halymenia schizymenioides	F	4-sub	X	-	-
Grateloupia doryphora	A	4	X	-	Sheltered areas
G. setchellii	R	4	X	-	-
Cryptonemia ovalifolia*	A	-	X	-	-
Prionitis australis	O-F	4-sub	X	-	-
P. lanceolata	A	2-sub	X	-	-

APPENDIX 3 Continued

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
P. linearis	A	4	X	–	Course sand
P. lyallii	C	4-sub	X	–	–
Erythrophyllum delesserioides	A	4	X	–	Heavy surf
Callophyllis crenulata	A	4-sub	x'	–	–
Callophyllis firma*	F	4-sub	X	–	–
C. linearis	A	4-sub	X	–	–
C. pinnata	A	4-sub	X	X	Epizoic
C. violacea	A	4-sub	X	–	–
Order Gigartinales					
Blinksia californica*	–	4	–	–	–
Petrocelis franciscana	C	2-3	X	–	–
Schizymenia pacifica	C	4-sub	X	X	–
Neoagardhiella baileyi	C	4-sub	X	–	Mostly near sand
Plocamium cartilagineum	C	IT-sub	X	–	In sand
P. violaceum	C	3	X	–	Heavy surf
Gracilaria robusta	F	4-sub	–	–	–
G. sjoestedtii*	C	3-sub	X	–	Buried in sand
Ahnfeltia plicata	C	3-4	–	–	Buried in sand
Gymnogongrus linearis	C-A	3-4	X	–	Sand swept
Ozophora latifolia	I	4-sub	X	–	–
Gigartina sp. (1)	–	x	–	–	Partially protected areas
G. agardhii	F-C	2-3	X	–	–
G. canaliculata	A	3-4	X	–	–
G. corymbifera	C	4-sub	X	–	Surf areas
G. harveyana	A	4	X	–	In fine sand
G. leptorhynchos	C	4	X	–	–

APPENDIX 3 Continued

Species	Abun	Zone	Substrate		
			Rock	Epiphyte	Other
G. papillata	C	2-3	X	-	-
G. spinosa	F	4	X	-	Exposed to surf
G. volans	A	4-sub	-	-	Sand scoured areas
Iridaea cordata	C-A	4-sub	-	-	-
I. cordata var. splendens	A	-	X	-	Exposed coast
I. flaccida	A	3-4	X	-	-
I. heterocarpa	C	3	X	-	-
I. lineare	A	4	X	-	Exposed coast
Rhodoglossum affine	A	3	X	-	-
R. californicum	C	4-sub	X	-	In sandy areas
R. roseum*	F	4-sub	X	-	Exposed coasts
Order Rhodymeniales					
Halosaccion glandiforme	A	2-3	-	-	-
Botryocladia pseudodichotoma	F-A	4-sub	X	-	-
Rhodymenia californica var. californica*	F-C	4-sub	X	-	-
R. pacifica*	F-C	4-sub	X	-	-
Coeloseira compressa	F	3-sub	X	X	-
Gastroclonium coulteri	C	IT-sub	X	-	-
Order Ceramiales					
Antithamnion defectum	C	IT-sub	-	X	-
A. kylinii	C	It-sub	-	X	-
Antithamnionella glandulifera	C	4	-	X	-
A. pacifica var. uncinata	C	-	-	X	-
Scagelia occidentale	C	4-sub	X	X	-
Platythamnion pectinatum	C	4-sub	X	-	-
P. recurvatum	O	4	X	-	-

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
Cryptopleura corallinara	C	4	-	X	On corallines
C. lobulifera*	F	4	X	X	-
C. violacea	F-A	4-sub	X	X	-
Botryoglossum farlowianum	C	4-sub	X	-	-
Herposiphonia plumula	F	3-sub	X	X	-
H. verticillata	C	4	-	X	-
Pogonophorella californica	F	3-sub	X'	-	-
Polysiphonia hendryi var gardneri	C	2	X	-	-
P. hendryi var hendryi	F	4	-	X	-
P. pacifica var pacifica	F	4-sub	X	-	Pilings
P. pacifica var determinata	C	4	X	-	-
P. pacifica var distans	O	-	X	-	-
P. paniculata	-	4	X	-	Sand swept
P. scopulorum var villum	F	-	X	X	-
Pterosiphonia baileyi	F	IT-sub	X	-	-
P. bipinnata	F	3-sub	X	-	Exposed coast
P. dendroidea	C	3-sub	X	-	-
Amplisiphonia pacifica	F	3-sub	X	X	-
Chondria decipiens*	F	2-4	X	-	Pilings
Laurencia blinksii	F	4	X	-	-
L. crispa*	O-A	2-4	-	-	-
L. pacifica	C-A	4	-	-	-
L. spectabilis var spectabilis	F-C	3-4	-	-	-
Erythrocystis saccata	C	4	-	X	-
Janczewskia gardneri	O-F	4-sub	-	-	Parasite

APPENDIX 3 Continued

Species	Abun	Zone	Substrate		
			Rock	Epiphyte	Other
VASCULAR PLANT					
Phyllospadix scouleri					

Ref. for algae lists

Pacific Grove

Smith, 1944.

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Plocamia igzo	U	4	-	8			X*	
Spheciospongia confoederata	R	4	-	8,25			X*	
Cliona celata californiana	P	3-4	Boring	6,8	X*			
Tethya aurantia	C	3-4	Under rock	8,25			X*	
Tetilla arb	U	4	-	-			X	
Class Calcarea								
Leucosolenia eleanor	C	4	Under rocks	25	X			
Leucilla nuttingi	C	3-4	-	25	X			
PHYLUM CNIDARIA								
Class Hydrozoa								
Garveia franciscana	P	-	-	6	X			X
Syncoryne eximia	P	-	Rocks	3,10	X		X	
Eudendrium californicum	A	4	Rocks/semi-protected	10,25	X			
Tubularia marina	P	3-4	Solitary protected	3,10,25	X		X	
Campanularia spp.	P	4	-	3,10,25	X		X	X
Gonothyraea spp.	P	-	-	10	X			
Calycella syringa	P	-	On algae	3			X	X
Halecium spp.	P	4	-	6,10,25			X	X

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Aglaophenia spp.	P	4	-	6,10	X		X	X
Plumularia spp.	P	4	-	10,25	X		X	X
Abietinaria spp.	C	3	Rocks	6,10,25	X			X
Sertularella spp	P	-	-	3,21			X	X
S. turgida	P	-	-	3	X		X	X
Hydractinia milleri	P	3	-	3			X	
Class Anthozoa								
Anthopleura elegantissima	C	3	-	11,25			X	
Anthopleura xanthogrammica	P	4	-	6,25	X			
Epiactis prolifera	C	3-4	On rocks algae	21,25			X	
Tealia coriacea	P	3-4	In sand	14,21	X			
Diadumene lighti	P	-	In sand	14				X*
Metridium exilis	P	-	Under rocks	15			X	X
Balanophyllia elegans	P	3-4	Protected	21,25	X		X	
Corynactis californica	C	3-4	Protected	13,25			X	
PHYLUM PLATYHELMINTHES								
Order Polycladida								
Freemania litoricola	P	3	Under rocks	16				X
Stylochoplana gracilis	P	-	On macrocystis	16	X			

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Dynamenella dilatata	C	4	Under rocks	7			X	
D. benedicti	C	3	On corallines	7			X	X
D. glabra	C	-	On corallines	7			X	
Ligia occidentalis	P	Splash	-	7,25	X		X	X
Order Eucarida								
Spirontocaris prionota	P	4	Rocky	21			X	
Heptacarpus paludicola	P	3-4	Under rock	6,21	X		X	
Alpheus sp.	P	4	Under rock	25			X	
A. dentysis	P	-	-	6			X	
Crangon sp.	P	-	Course sand	21			X	
Cragon dentysis	P	-	-	21				
Loxorhynchus crispatus	P	-	-	21			X	
Mimulus foliatus	P	4	Under rock	21			X	
Pugettia gracilis	P	4	-	21			X	
P. producta	P	4	-	21,25			X	
P. richii	P	-	-	21			X	
Scyra acutifrons	P	4	Under rock	21,25			X	
Cancer anthonyi	P	-	-	21			X	
C. antennarius	P	4	-	21,25			X	

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Stylochus tripartitus	P	-	On kelp	16	X*			
Eurylepta aurantiaca	P	-	Under rocks	16	X			
Notoplana acticola	C	2-4	Under rocks	16				X
PHYLUM ANNELIDA								
Class Polychaeta								
Family Polynoidae								
Halosydna brevisetosa	C	-	Rocks	6		X		
Family Nereidae								
Nereis sp.	P	-	-				X	X
Family Lumbrineridae								
Lumbrineris sp.	P	-	Sand	6				X
Family Serpulidae								
Spirorbis sp.	C	-	Rocks	4				X
PHYLUM ANTHROPODA								
Family Cirripedia								
Balanus glandula	C	1	Rocks	11			X	X
Chthamalus fissus	C	1	Rocks	11			X	X
Order Isopoda								
Idotea wosnesenskii	C	-	On kelp	-			X	

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Lophopanopeus bellus	P	–	–	21			X	
L. heathii	P	–	–	21			X	
Pinnixia occidentalis	P	–	–	21			X	
Hemigrapsus nudus	P	3	Protected	21			X	
H. oregonensis	P	–	–	21			X	
Pachygrapsus crassipes	P	2–3	On rock & *Pelvetia*	11,25			X	X
Pagurus granosimanus	P	2	–	21,25	X		X	
P. hemphilli	P	3–4	–	21			X	
P. hirsutiusculus	C	–	–	11,21			X	X
P. samuelis	C	2	–	21,25	X		X	
Cryptolithodes sitchensis	P	4	Under rock	21,25			X	
Hapalogaster cavicauda	C	4	Under rock	21,25			X	
Pachycheles rudis	O	4	Under rock	–			X	
Petrolisthes cinctipes	C	2–3	Under rock	–			X	
PHYLUM MOLLUSCA								
Class Cephalopoda		3–4	–	21				
Class Polyplacophora								
Callistochiton crassicostatus	P	4	Under rock	12,25			X	
Nuttallina californica	A	–	–	6,12,20			X	

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Chaetopleura gemma	C	–	–	6,26			X	
Cyanoplax dentiens	C	2–3	On abalone	11,12,21,26			X	X
C. fackenthallae	S	–	–	5	X			
C. hartwegii	C	3–4	Under corallines	11,12,21,26	X			X
Ischnochiton regularis	C	3–4	Under rocks	12,21,26			X	
Lepidozona mertensii	P	4	Under rocks	21,25			X	
Stenoplax heathiana	C	4	Under rocks	12,21,26			X	X
Tonicella lineata	C	2–4	–	12,21,26			X	X
Dendrochiton thamnoporus	S	4-sub	Under rocks	21,26			X	
Katharina tunicata	C	4	On rock	21,25			X	
Mopalia ciliata	P	3–4	–	6,12,21			X	
M. hindsii	P	–	–	12,21			X	X
M. lignosa	P	4	–	12,21,25			X	X
M. muscosa	C	4	Under rock	21,25			X	X
Placiphorella velata	C	4	Under rock	12,21,25			X	
Class Gastropoda								
Sub Class Prosobranchia								
Haliotis rufescens	P	4	–	21,25			X	
Fissurella volcano	P	2	On rocks	21,25			X	

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Diodora aspera	C	-	-	6,26			X	
Megatebennus bimaculatus	C	4-sub	Rock	21			X	
Collisella digitalis	C	1	Sides rock	10			X	
C. limatula	P	3	-	10,11,25			X	X
C. ochracea	S	4	Rocks	6,26	X			
C. pelta	P	2	-				X	X
C. scabra	P	2	Tops rocks	10,25				X
Lottia gigantea	P	1	-	10,25			X	X
Notoacmea insessa	P	4	With Egregia	21,25			X	
N. scutum	C	3-4	Rocks	10,1125			X	X
Tegula brunnea	C	3-4	-	21,25			X	
T. funebalis	A	2	On rocks	10,11,25				X
Littorina planaxis	A	Splash 1	-	11,25	X			
L. scutulata	C	2	-	11,25			X	X
Serpulorbis squamigerus	P	2	-	6,21			X	
Bittium sp.	P	-	-	11			X	
B. interfossa	P	-	Under algae	25			X	
Erato vitellina	P	4-sub	-	21			X	

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Ceratostoma foliatum	A	3	–	6,25			X	
Acanthina spirata	C	2	–	21,26			X	
Nucella emarginata	A	2	–	10,21			X	X
Amphissa versicolor	P	–	In gravel	10				X
Sub Class Opisthobranchia								
Chelidonura inermis	P	–	–	17	X			
Berthella californica	P	–	–	21			X	
Acanthodoris hudsoni	P	–	–	19,26			X*	
Aegires albopunctatus	P	–	–	17,26	X		X	
Ancula pacifica	P	–	–	17,19			X	
Anisodoris nobilis	P	–	–	21,26			X	
Cadlina flavomaculata	S	–	–	17			X	
Cadlina luteomarginata	S	–	–	19,21			X	
C. modesta	P	–	–	19			X*	
Corambe pacifica	P	–	–	19	X*			
Coryphella trilineata	P	–	–	17			X	
Dendronotus albus	P	–	–	19			X*	
D. frondosus	P	–	–	17			X	
D. subramosus	P	–	–	19			X	

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Diaulula sandiegensis	P	-	-	19	X			
Dirona albolineata	R	-	-	26			X	
Dirona picta	C	-	-	17,26	X		X	
Discodoris heathi	S	-	-	21,26			X	
Doriopsilla albopunctata	P	-	-	17,21	X		X	
Doto amyra	P	-	-	17			X	
D. kya	P	-	-	17,19			X*	
Eubranchus rustyus	P	-	-	19			X	
Flabellinopsis iodinea	S	-	-	26			X	
Hancockia californica	S	-	-	17,19,26	X		X	X
Hermissenda crassicornis	C	-	-	17,21,26			X	
Hopkinsia rosacea	C	-	-	17,20,26	X		X	X
Laila cockerelli	S	-	-	6,19,26			X	
Rostanga pulchra	A	-	-	17,20,21,26			X	X
Trinchesia abronia	P	-	-	19			X	
Trinchesia fulgens	P	-	-	19			X	
T. virens	P	-	-	19			X*	
Triopha carpenteri	C	3	-	25,26			X	
T. grandis	P	-	-	6	X			

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
T. maculata	C	–	–	6,17,26			X	
Tritonia festiva	P	–	–	19,21,26	X*		X	
Polycera atra	A	–	–	26			X	X
Class Bivalvia								
Chama pellucida	C	4	Under rock	25,26			X	
PHYLUM ECTOPROCTA								
Filicrisia franciscana	P	–	–	24				X
Caulibugula ciliata	P	3	On abalone shells	21,22	X		X	
Membranipora fusca	P	–	–	22				X*
M. membranacea	P	4	–	21			X	
Arthropoma cecili	P	–	–	23			X	
Eurystomella bilabiata	P	4	Under rock	21,25	X		X	
Microporella ciliata	P	–	–	23				X
M. cribrosa	P	–	–	23				X
PHYLUM ENTOPROCTA								
Barentsia ramosa	P	–	–	24	X			
PHYLUM SIPUNCULA								
Golfingia hespera	P	–	–	9	X			
G. margaritacea californiensis	P	–	–	9	X*			

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Themiste pyroides	P	-	-	6,9	X			
T. dyscrita	P	-	-	9				X*
Phascolosoma agassizi	P	-	-	9,21			X	
PHYLUM ECHINOCLERINATA								
Class Asteroides								
Leptasterias hexactis	C	-	-	11			X	X
Pisaster ochraceus	C	4	-	25	X			
Class Ophiuroidea								
Amphiodia occidentalis	P	-	-	18,21	X		X	
Ophiopholis aculeata	O	4	Under rock	21,25	X		X	
Ophioplocus esmarki	P	3	Under rock	25	X			
Ophiopteris papillosa	O	4	Under rock	25	X			
Ophiothrix spiculata	P	4	Under rock	18,21,25	X		X	
Class Holothursidea								
Leptosynapta sp.	P	-	-	21			X	
PHYLUM CHORDATA								
Subphylum Urochordata								
Aplidium arenatum	P	-	-	1	X*		X	X
A. californicum	P	-	With tunicates	1,21			X	

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
A. solidum	C	4	–	1,21			X	
Archidistoma psammion	C	–	–	1,21			X	
A. ritteri	C	3-4	With Isopod	1,21			X	
A. diaphanes	P	–	–	1				X
Clavelina huntsmani	C	3-4	Semi-colonial	21,25			X	
Cystodytes lobatus	P	–	–	1			X	
Didemnum carnulentum	C	3-4	–	1			X	
Diplosoma macdonaldi	P	–	Small colonies	21			X	
Euherdmania claviformis	P	3-4	Protected ledges	1,25			X	X
Ritterella pulchra	C	3-4	Protected ledges	1,21			X	
Perophora annectens	C	4	Coves	21			X	
Synoicum pellucidum	P	–	–	21			X	
Metandrocarpa taylori	C	–	–	–			X	
Styela montereyensis	C	–	–	1				X
FISHES								
Clinocottus analis	P	–	–	27			X	X
C. recalvus	C	4	–	2,27	X*		X	X
Oligocottus snyderi	P	3	–	2,27	X*		X	X
O. rubellie	P	–	–	2,27	X*		X	X

APPENDIX 4 Continued

Species	Abun	Zone	Substrate	Source	Pacific Grove	Monterey Peninsula	Point Pinos	Hopkins
Gibbonsea metzi	P	-	-	27			X	
G. montereyensis	P	-	-	21	X			
Cebidicthys violaceus	P	-	-	21	X			
Xiphister atropurpureus	P	-	-	21,27			X	X
X. mucosus	P	-	-	27			X	X

* Indicates type from this locality

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Appendix 5: List of marine mammals and sea birds observed in or near the ASBS. (after Baldridge).

Introduction: Between 1969 and 1973, Alan Baldridge, librarian for Hopkins Marine Station, recorded his observations of marine mammals and sea birds in Monterey Bay. These observations, and those of other reliable individuals, are recorded in the CALCOFI reports for those years. As the reports give the specific location of the observation, it is possible to extract those sightings which were made in the vicinity of the ASBS. Listed below are species whose occurrence in the ASBS is seasonal or relatively uncommon. In addition to those listed below, the ASBS is utilized by many resident inshore species such as cormorants and harbor seals.

A. Marine mammals. Occurrence within the ASBS is often associated with seasonal migration; generally these migrations take place further offshore but a few individuals stray this close to shore. Pinnipeds seen in the ASBS are sometimes sick or weaker individuals rather than part of the main body of the population.

1. California Gray Whale (*Eschrictius gibbosus*)

Fall - part of southward migration; early spring - part of northward migration. Mating activity observed near Hopkins Marine Station in January 1971.

2. Minke Whale (*Balaenoptera acutorostrata*)

Individuals observed just outside kelp beds.

3. Killer Whale (*Orcinus orca*)

Usually in small pods. Observed once foraging in kelp beds.

4. Humpback Whale (*Megaptera novaeangliae*)

One observed off Lovers Point in the fall.

5. White-sided or Pacific Striped Dolphin (*Lagenorhynchus obliguidens*)

6. Harbor Porpoise (*Phocoena phocoena*)

7. Northern Elephant Seal (*Mirounga angustirostris*)

B. Pelagic sea birds. Sea birds observed this close inshore are often seeking shelter from storms, or following the inshore migration of species on which they feed (such as squid or other bird species). It is not uncommon for migrating sea birds to occur in the bay in large numbers some years, and be entirely absent other years.

1. Fulmar (Fulmarus glaciialis)

Influx associated with inshore occurrence of Mola mola in the fall.

2. Sooty Shearwater (Puffinus frieseus)

Large numbers sometimes seen in ASBS from April-July, feeding on squid which have moved in to shallow water to spawn.

3. New Zealand Shearwater (Puffinus bulleri)

Small numbers, in the fall.

4. Pink-footed Shearwater (Puffinus creatopus)

In the fall, sometimes in large numbers.

5. Manx Shearwater (Puffinus puffinus)

In the winter, uncommon.

6. Parasitic Jaeger (Stercorarius parasiticus)

In the fall; occurrence of substantial numbers associated with the migration of Heerman's Gull and Elegant Tern, prey species.

7. Pomarine Jaeger (Stercorarius pomarinus)

In the fall; uncommon; also associated with the occurrence of terns, gulls, and shearwaters (prey species).

8. Elegant Tern (Thalasseus elegans)

Fall migrant from the south, large flocks sometimes observed in kelp beds.

9. Common Tern (Sterna hirundo)

Rare.

10. Bonaparte's Gull (Larus philadelphia)

Spring and fall migrant; large flocks observed.

11. Sabines Gull (*Xema Sabini*)

In small numbers.

12. Red Phalarope (*Phalaropus fulicarius*)

Fall and spring migration through the area; sometimes large numbers observed inshore in the fall.

13. Northern Phalarope (*Lobipes lobatus*)

Sometimes observed as northbound migrant in early summer months.

14. Ashy Petrel (*Oceanodroma homochroa*)

Usually inshore only during a severe storm.

15. Fork-tailed Petrel (*Oceanodroma furcata*)

Usually inshore only during a severe storm.

16. Leach's Petrel (*Oceanodroma leucorhoa*)

Usually inshore only during a severe storm.

17. Black-legged Kittiwake (*Rissa tridactyla*)

Fall and spring migrant; sometimes a summer population near Pt. Pinos.

18. Black-footed Albatross (*Diomedea nigripes*)

Uncommon inshore.

19. Common Murre (*Uria aalge*)

Winters here; large numbers sometimes seen in late summer with juveniles.

20. Ancient Murrelet (*Synthliboramphus antiguum*)

Occurs inshore sometimes during winter storms.

21. Cassin's Auklet (*Ptychoramphus aleutica*)

Occurs inshore sometimes during winter storms.

22. Marbled Murrelet (*Brachyramphus marmoratum*)

Very uncommon; near Pt. Pinos.

23. Rhinoceros Auklet (*Cerorhinca monocerata*)

Winter resident; sometimes inshore in large numbers.

24. Tufted Puffin (*Lunda cirrhata*)

Rare.